National Aeronautics and Space Administration

Ames Research Center
Moffett Field, California 94035

November 12, 2015

Ms. Julianne Polanco
State Historic Preservation Officer
Office of Historic Preservation
Department of Parks & Recreation
1725 23rd Street, Suite 100
Sacramento, CA 95816

Attn: Mr. Mark Beason

Subject: NASA Section 106 Consultation: Arc Jet Complex Steam Vacuum System Boiler Replacement Project at Ames Research Center, Moffett Field, California

Dear Ms. Polanco:

As part of its responsibilities under Section 106 of the National Historic Preservation Act (NHPA), the National Aeronautics and Space Administration (NASA) is requesting consultation for the Arc Jet Complex Steam Vacuum System (SVS) Boiler Replacement Project (project or undertaking) located at Ames Research Center (ARC) at Moffett Field, California (Attachment A). NASA has determined that this project constitutes an undertaking under the NHPA. NASA requests review and consultation concerning the following project description, identification efforts, and effects analysis for the project, and the State Historic Preservation Officer's (SHPO) concurrence that NASA's finding of no adverse effect is appropriate, pursuant to 36 Code of Federal Regulations (CFR) 800.5(b).

Description of the Undertaking

The project proposes to construct a new, fully functional boiler plant (to be known as N234B) to replace the existing boiler plant in support of the Arc Jet Complex at ARC. The Arc Jet Complex is composed of several structures, including Building N238, the Arc Jet Laboratory, which has been determined eligible for the National Register of Historic Places (NRHP) and has a pending NRHP nomination. The Arc Jet Complex has existing SVS boiler equipment inside of Building N234A on the west side of Mark Avenue that will be removed. The proposed new boiler plant, Building N234B, will be located on the east side of Mark Avenue, to the north of Building N242, on the site of Building N252 where a 30,000-gallon tank and 40,000-gallon tank are currently installed (see Primary Area of Work in Attachment B and Plate 1).

The proposed boiler plant will include three low-emission, high-pressure steam boilers installed on a reinforced concrete mat slab foundation, and related mechanical equipment, tanks, valves, and piping. The boiler facility will be covered with a structural steel canopy and will have an attached prefabricated boiler control room. The project will also include the relocation of the 30,000-gallon and 40,000-gallon tanks, and the removal and relocation or replacement of existing site utilities, fencing, and tank foundations.

Plate 1. Primary area of work, view facing southwest (N242 in background at left; N238 in background at right).

Minor earthwork will include steam pipe utility trenching, grading, drainage improvements, and site restoration. Other activities under this project will include:

- improvements to Building N231 with HVAC upgrades, interior changes to the restroom, and exterior repainting;
- demolition of Building N234A and the existing SVS boiler and feedwater deaerating (FWDA) system and specific mechanical equipment (obsolete piping, pumps, controls, instruments, and electrical power) located inside; and
- construction of a new boiler shop building to the north of the proposed N234B. The proposed boiler shop building (to be known as N234C) will be a one-story, 20-foot by 40-foot utilitarian building with a concrete floor, steel structure, standing seam aluminum roof and insulation, aluminum siding and insulation, and steel doors.

Project activities are illustrated on the site plan provided in Attachment C, and in architectural drawings provided in Attachment D.

Area of Potential Effects

The area of potential effects (APE) is defined to encompass the first tier of buildings adjacent to the project's footprint. The APE is shown in Attachment B. Where the project proposes only interior work to a building, the APE is limited to the footprint of that building. For archaeological resources, the APE is defined as the limits of disturbance, including areas of temporary staging and construction ground disturbance. The proposed APE boundary includes all historic properties that may be indirectly affected by the project.

Identification of Historic Properties

The APE has been previously surveyed for archaeological and architectural resources, and one architectural resource has been previously evaluated for NRHP eligibility.

No archaeological resources or areas of high archaeological sensitivity have been previously identified in or around the APE for archaeological resources. The project area that will contain ground disturbance is primarily an open dirt lot adjacent to Building N242 and under existing roads. The area is disturbed, and no new archaeological survey was performed. The area was not identified in the 2014 Draft Integrated Cultural Resources Management Plan for ARC (AECOM 2014) as having high archaeological sensitivity.

An intensive survey of the APE was conducted on May 22, 2015. The survey identified six buildings that are at least 50 years old and located within the APE (Table 1). The remaining buildings and structures in the APE are not yet 50 years old, do not exhibit the potential for exceptional significance, and, therefore, were not evaluated. For full descriptions and evaluations of the resources under the NRHP Criteria, see DPR 523 series forms located in Attachment E.

Table 1. Historic-Era Architectural Resources in the APE

Building No.	Historic Name (Current Name)	Year Built	NRHP Status
N144	General Warehouse	1952	Not Eligible
N231	Hypersonic Helium Tunnel (Arc Jet Shops)*	1960	Not Eligible
N234	Gasdynamics Laboratory (Thermal Protection Laboratory)*	1962	Eligible
N234A	Boiler/SVS Vacuum Ejector and Boiler Control System*	1962	Not Eligible
N238	Mach 50 Helium Tunnel (Arc Jet Laboratory)*	1964	Nominated for listing (pending)
N242	Structural Dynamics Laboratory (Systems Development Facility)	1965	Eligible

* Currently part of the Arc Jet Complex

The Arc Jet Complex, located in the APE, currently employs Buildings N231, N234, N234A, N238, and the SVS with its associated cooling towers (Plate 2). Although Building N231 supports the Arc Jet Complex, it was evaluated separately according to its historical construction, use, and associations. The main buildings that compose the Arc Jet Complex are also discussed individually.

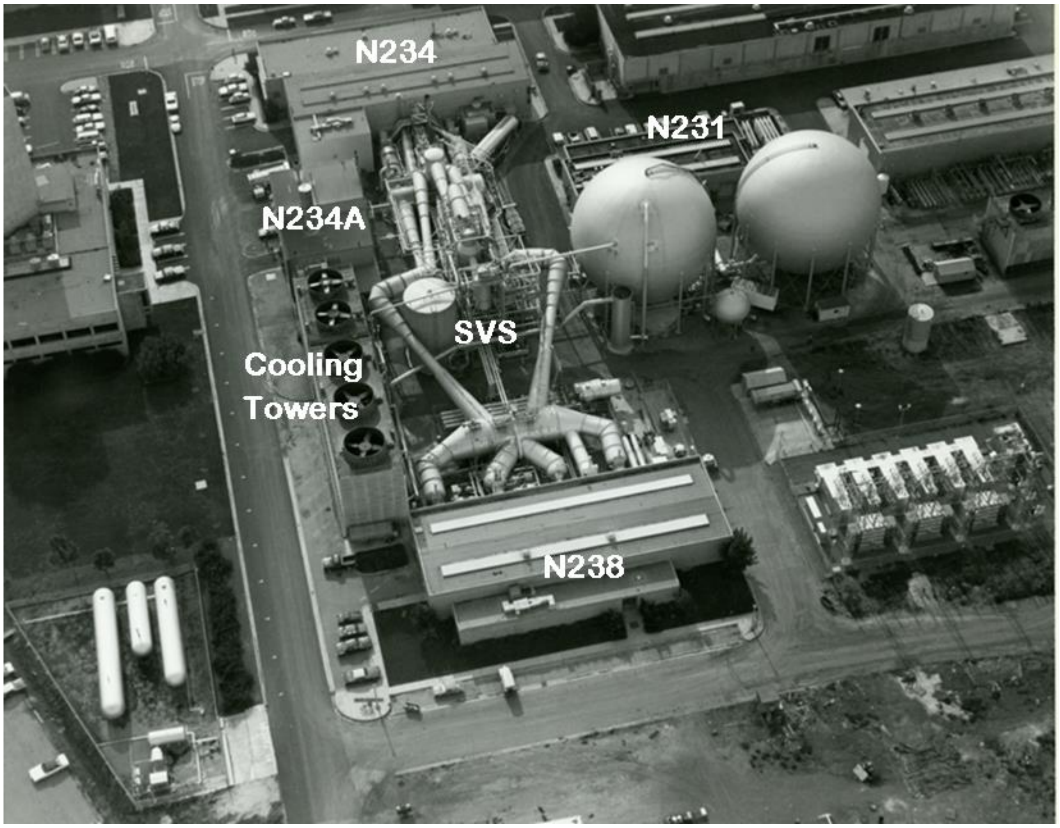


Plate 2. The Arc Jet Complex, circa 1974 (Primary area of work is located at lower left.)

Arc Jet Complex

Building N234 – Gasdynamics Laboratory (Thermal Protection Laboratory)

Building N234 is a 24,670-square-foot, two-story laboratory and office building with a concrete foundation, an asymmetrical plan, reinforced concrete walls, and a flat roof (Plate 3). The building has two distinct parts: an office portion on the south side (front), and a laboratory portion on the north side (rear). The front of the building has concrete exterior walls that are scored in a grid pattern. Each story on the south side and east side contains a series of continuous aluminum-framed fixed windows some with hopper or awning sash and a flat concrete awning projecting over the windows. The offset central entrance contains a recessed pair of glazed doors with a transom and projecting concrete awning above, flanked by full-height brick pilasters. The west side contains no fenestration and has an attached brick partition wall enclosing the area around it (Plate 4). The rear portion of the building is clad with corrugated metal siding and has an L-shaped plan. The east side contains a single glazed door and a roll-up steel utility door in the first story, and an exterior staircase leading to a single glazed door in the second story. The rear of the building is connected to SVS equipment.

Constructed in 1962, Building N234 and its related SVS equipment were built as the Gasdynamics Laboratory and were used for research in heat shield applications and aerodynamics for spacecraft reentry into Earth's atmosphere.

Plate 3. Building N234, view facing northwest.

Plate 4. Building N234, view facing northeast.

SVS

The SVS is composed of a warren of metal tubes, valves, structural supports, tanks, and cooling towers (Plate 5). The SVS was first built as part of Building N234 in 1962, and was later expanded to connect to Building N238. It is integral to the operation of the Arc Jet Complex. The

SVS is powered by the existing boiler in Building N234A (described below). The cooling towers are connected to the SVS to the east (Plate 6). The cooling towers consist of five aligned cylindrical towers with vents housed in a rectangular, two-story structure that is clad in corrugated metal and vented in the first story.

Plate 5. SVS, view facing northeast.

Plate 6. Cooling towers, view facing northwest.

Building N234A – Boiler/ SVS Vacuum Ejector and Boiler Control System

Building N234A is a three-story building with a concrete foundation, a steel-frame structural system, and a dual shed roof (Plate 7). The roof is covered with corrugated metal, and several vents and a large cylindrical pipe project from it. The exterior is clad with corrugated metal siding. On the east and west sides of the building, each story contains a series of steel-sash, industrial windows with operable awning window panels in the center. The east side also contains a roll-up steel utility door that has been modified to contain a single glazed steel door. The west side of the building has an exterior staircase attached that leads to a single steel door in the second story and pipes that extend from the building to connect to the SVS. The south side contains a single glazed steel door and is connected to an adjacent three-story structure that holds a series of tanks (Plate 8). The north side of Building N234A has a one-story shed addition and a vent in the second story.

Plate 7. Building N234A, east side, view facing southwest.

Plate 8. Building N234A, east side, view facing northwest.

Building N238 – Mach 50 Helium Tunnel (Arc Jet Laboratory)

Building N238 has a utilitarian design composed of two distinct sections: a one-story L-shaped portion with brick exterior walls, and a corrugated metal structure one and one-half stories high situated within the ell of the brick portion and extending to the south and west (Plates 9 and 10). The building has a 17,030-square-foot rectangular plan with a concrete foundation, a steel-frame structural system, and a flat roof. The façade (north elevation) of the brick portion contains two windows in the eastern portion and an entrance with glazed double-doors in the western portion. The east side of the brick portion extends the full width of the building and contains a steel overhead utility door. The west side of the brick portion and the north side of the corrugated metal portion have no fenestration. The west side of the corrugated metal portion contains a steel overhead utility door and a single man-door. The rear (south elevation) of Building N238 is connected to the SVS. The building's interior at one time contained five discrete test bays: the 60-megawatt Interaction Heating Facility, the Direct Connect Facility; the Panel Test Facility; the Giant Planet Facility; and the High Enthalpy Facility.

The Arc Jet Laboratory (Building N238) was determined eligible in 2007 under Criterion A at the national level of significance for its association with NASA's Space Shuttle Program (SSP), specifically for the research and development of Thermal Protection Systems (TPS) for the space shuttle conducted in its 60-megawatt Interaction Heating Facility. The period of significance is 1968 to 2011, the year of its construction to the end of the SSP. The property also meets Criteria Consideration G for properties that have achieved significance within the past 50 years. The significance of Building N238 was measured according to NASA's guidelines published in *Evaluating Historic Resources Associated with the Space Shuttle Program: Criteria of Eligibility* *for Listing in the National Register of Historic Places (NRHP)* (NASA 2006) (Page & Turnbull 2007). Building N238 has been individually nominated for the NRHP (pending November 2015).

Plate 9. Building N238, view facing southwest.

Plate 10. Building N238, view facing southeast.

Constructed 1962–1964, the Arc Jet Complex is associated with scientific innovation and the development of arc jet technology. The arc jets designed and built in the complex contributed to the successful development of TPS technology related to NASA's mission to achieve manned spaceflight and a lunar landing in the 1960s. TPS technology was critical for the successful reentry of spacecraft related to every NASA space program, including Apollo, Space Shuttle, Viking, Pioneer-Venus, Galileo, Mars Pathfinder, MER heatshield, Stardust, NASP, X-33, X-34, SHARP-B1 and B2, X-37 WLE TPS and most recently CEV/Orion heatshield development and Mars Science Laboratory TPS. The unique invention of high-powered arc jets that approximately simulated the conditions upon entry into the Earth's atmosphere to develop TPS technology originated in the test areas of the Arc Jet Complex. The Arc Jet Complex is eligible for the NRHP under Criterion A for its association with the creation and operation of the arc jets, its contributions to important TPS research related to space exploration, for a period of significance from 1962, the year that the Gasdynamics Laboratory was completed, to 2011, the end of the SSP and NASA-directed manned spaceflight. Building N234 (formerly Gasdynamics Laboratory, now Thermal Protection Laboratory), the SVS, and Building N238 (formerly Mach 50 Helium Tunnel, now Arc Jet Laboratory) are the primary features of the Arc Jet Complex that meet this criterion. The property retains integrity, and is eligible for listing in the NRHP.

The boiler inside of Building N234A has supported the SVS since it was constructed as part of the Gasdynamics Laboratory in 1962, but is an auxiliary feature of the complex and is not directly related to the significant scientific research related to arc jets and space exploration that has taken place within the laboratories. The boiler itself was built for a Navy ship, the 1945 *U.S.S. Helena*, and repurposed for the laboratory. Building N234A (SVS boiler), although dating to the period of significance, is a secondary feature of the Arc Jet Complex, and does not achieve a level of significance to be eligible.

Building N144 – General Warehouse

Building N144 is a warehouse located along the east side of Walcott Avenue, to the east of the project area and the Arc Jet Complex (Plate 11). The one-story warehouse has a concrete slab foundation, a steel-frame structural system, corrugated cement-asbestos siding, and a low-pitched gable roof. It is 20 bays long with concrete firewalls between every five bays, and two bays wide. The bays contain regularly spaced access openings, primarily with roll-up steel utility doors. There are also some glazed doors and metal sliding windows. The majority of roll-up steel utility doors are located on the west side facing Walcott Avenue. Building N144 has had some minor changes, including the addition of new access openings and the replacement of utility doors, but does not appear to have had any major alterations.

Built in 1952, Building N144 has continuously served a support function as a warehouse and does not meet the NRHP Criteria because it does not exhibit historical significance tied to any particular themes, events, individuals, or architectural significance related to its design, materials, type, or materials. It is not eligible for the NRHP.

Plate 11. Building N144, view facing north.

Building N231 – Hypersonic Helium Tunnel

Building N231 is a one-story, 7,400-square-foot building with a steel-frame structural system, a concrete foundation, and a flat roof (Plate 12). The building has a roughly rectangular plan with two distinct parts: an office area on the south (front) side, and a testing area/warehouse on the north (rear) side. The front of the building has brick siding and a hipped canopy covered with standing seam sheet metal and supported by plain posts along the south and east sides. Inset under the canopy, the exterior walls contain a series of aluminum-framed fixed windows (Plate 13). The offset central entrance contains a recessed pair of glazed doors with a transom above, flanked by brick piers. The rear portion of the building is a half story taller, and is clad with corrugated metal siding and stucco or concrete siding. The east and west sides each contain a roll-up steel utility door and a single door. The north side of the building is attached to a helium spherical evacuation recovery tank and other equipment. Other equipment is located to the west of the building behind a brick partition wall.

Built in 1960 as the 20-inch Hypersonic Helium Tunnel facility, Building N231 has undergone substantial alteration. Originally connected to two helium spherical tanks and other research equipment that composed the 20-inch Hypersonic Helium Tunnel, the building no longer serves that function since the helium tunnel was dismantled and one helium spherical tank was removed. An addition to the north side of the building doubled the size of the rear portion of the building, and utility doors were installed at an undetermined date. Currently, the building is used for offices and a shop related to the Arc Jet Complex. While significant under NRHP Criterion A for its association with the creation and operation of helium tunnels and its contributions to important scientific research related to space exploration when it was the Hypersonic Helium Tunnel, Building N231 does not retain sufficient integrity to be listed in the NRHP. Therefore, it is not eligible for the NRHP.

Plate 12. Building N231, view facing northwest.

Plate 13. Building N231, view facing northeast.

Building N242 – Structural Dynamics Laboratory (Systems Development Facility)

Building N242 is a two-story research facility with a rectangular plan and a prominent 100-foot-high pentagonal test chamber tower extending from the center of the building (Plate 14). The building has reinforced concrete walls that are scored with a grid pattern. The building and the tower have flat roofs. The building has two sections: the laboratory and test areas, including the tower, to the south, and offices and shops to the north. The sections are divided without internal access.

Plate 14. Building N242, view facing north.

Plate 15. Building N242, view facing southeast.

The south portion of the building containing the laboratory has a central, two-story bay enclosed with a sliding hangar door on the south side of the building that provides access to the laboratory test areas (pictured below). To the left, there is a two-story bay that contains corrugated metal siding with a pair of steel doors under a concrete canopy in the first story, and fixed metal-framed windows in the first and second stories. The east side of the building contains roll-up steel utility doors in the first and second stories, although the first story door has been modified with a single glazed steel door. The west side of the building contains no doors or windows. The east and west sides have regularly spaced vent openings in the second story.

The north portion of the building containing offices and shops has entrances on the east and west sides, each consisting of recessed glazed doors and surrounds under five, tall and narrow fixed windows with projecting concrete dividers. To the north of each entrance, a concrete mass projects from the building. The north side of the building has eight symmetrical bays containing narrow fixed clerestory windows in the first story and large, recessed, single-plate, fixed windows in the second story. Mechanical equipment is also located along the north side of the building.

Built in 1965, Building N242 was designed as the Structural Dynamics Laboratory. The facility was completed in 1965 with infrared heating, variable-frequency shakers, and noisemakers to simulate lift-off forces for testing missiles. By 1972, it was used for other purposes, including serving as the Mars Surface Wind Tunnel in the mid-2000s. Building N242 has had some alterations related to its repurposing for other scientific research. Currently, the building is still used for offices and scientific research. Building N242 is significant under NRHP Criterion A for its association as a highly specialized missile and spacecraft testing facility, and for its contributions to important scientific research related to space exploration. It is also distinctive as a specially designed Modern research facility with a prominent 100-foot-tall pentagonal tower, and meets NRHP Criterion C. The period of significance extends from 1964 to 1972, the year construction began until the Structural Dynamics Branch at ARC terminated and the building was repurposed for other uses. The Structural Dynamics Laboratory sufficiently retains its integrity of location, design, setting, materials, workmanship, feeling, and association to be eligible for the NRHP.

Affected Historic Properties

Affected properties include the Arc Jet Complex (Building N234, Building N238, and SVS) and Building N242. As described above, these resources are eligible for the NRHP.

Assessment of Effects

The Criteria of Adverse Effect pursuant to 36 CFR 800.5(a)(1) are applied to assess effects of the undertaking on historic properties within the APE:

> (1) Criteria of adverse effect. An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the NRHP in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Consideration shall be given to all qualifying characteristics of a historic property, including those that may have been identified subsequent to the original evaluation of the property's eligibility for the NRHP. Adverse effects may include reasonably foreseeable effects caused

by the undertaking that may occur later in time, be farther removed in distance, or be cumulative.

The project does not propose to alter any historic properties directly, and is not anticipated to have any direct effects on historic properties, with the exception of the potential to affect unknown subsurface archaeological resources. To address that potential, NASA will follow its standing operating procedures for unanticipated discoveries as outlined in the 2014 Draft Integrated Cultural Resources Management Plan (AECOM 2014).

The project has the potential for indirect effects through visual changes that may alter the setting of the Arc Jet Complex and N242. The new construction of Building N234B will introduce a visual intrusion adjacent to these historic properties and will change the power source for the Arc Jet Complex. Recommendations for new construction are equal to those for compatible new additions set forth in the Secretary of the Interior's Standards for Rehabilitation, specifically Standards 9 and 10.

Standard 9 states:

> New additions, exterior alterations, or related new construction shall not destroy historic materials that characterize the property. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment.

Standard 10 states:

> New additions and adjacent or related new construction shall be undertaken in such a manner that if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.

The project will not destroy any significant features that characterize the historic properties. Removal of the existing boiler in Building N234A will not diminish the integrity of the Arc Jet Complex, as it served a support function to the facility and was not directly associated with the research that makes the facility significant.

The main consideration for the new construction is how it will impact the setting of the Arc Jet Complex and N242. The buildings are research facilities that are significant for their innovation in scientific research related to space flight. The setting for these buildings is generally reflective of a research facility composed of industrial-type buildings made with common materials and construction methods. The function of the buildings rather than the setting is the more important aspect of their integrity that allows the historic properties to convey their historical significance. However, to be compatible with the setting, the proposed Building N234B will complement these buildings and the other existing facilities in the immediate area.

Buildings N234 and N238 share similar materials, including concrete, brick, and corrugated metal siding. Building N242 has concrete exterior walls and is two stories. Nearby industrial-type structures include sheds, storage facilities, and other steel-framed buildings clad primarily in concrete and corrugated metal siding of varying heights. New construction of Building N234B, which will be composed of a series of boilers with a steel-framed, approximately four-story-high corrugated metal canopy, will be compatible with the massing, size, scale, and materials of the historic properties and other buildings in the immediate vicinity. Differentiation from the adjacent historic properties will be evident through the profile of Building N234B's roof and the discernible differences in its contemporary materials. Furthermore, Building N234B's location across the street from the Arc Jet Complex and at the rear of Building N242 (approximately 35 feet away from the north side of the building) will be obscured within the main viewsheds of the buildings and their prominent façades, and will not affect the overall setting of the historic properties. The feeling of a research facility will be retained. Therefore, the project will be consistent with Standard 9.

The project proposes several actions that will not be feasibly reversible, including construction of Building N234B; removal and disposal of existing boiler equipment; relocation of 30,000- and 40,000-gallon tanks; and installment of underground utility lines. Building N234B will be a permanent facility. No new use of the existing boiler equipment is proposed, and its disposal will be permanent. The relocation of the tanks, one to a location on a paved lot behind Building N271 and the other to an area on the east side of Building N242, will not affect historic properties, as the buildings adjacent to the paved lot are not of historic age and do not exhibit exceptional significance, and the tanks are already adjacent to Building N242 to the north. Installment of underground utility lines will also require permanent infrastructure. However, the project proposes minimal connections to the Arc Jet Complex through the cooling towers of the SVS that will be reversible, and will not impair the essential form, character-defining features related to the laboratories and their equipment, or integrity of the adjacent historic properties. Therefore, the project will be consistent with Standard 10.

As a whole, the project will minimally alter the setting of the Arc Jet Complex and N242 with the removal and upgrade of utility sources in the new Building N234B boiler facility. Replacement of the SVS boiler will allow for the continued function of the research facility, a necessary upgrade to keep the laboratory capable of conducting the research that makes the historic properties significant. Periodic modifications to these research facilities are necessary for these facilities to continue their functions and maintain their significance under the NRHP Criteria. The project reflects guidance in the Advisory Council for Historic Preservation's (ACHP) 1991 *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities* (ACHP 1991) that accounts for the changing nature of scientific research facilities. The historic properties will continue to convey their historical significance and their integrity of location, design, materials, workmanship, and association, will not be diminished. Therefore, the project will result in no adverse effect.

Public Participation

Pursuant to 36 CFR 800.5(c), NASA will make its finding of no adverse effect for this undertaking available to the public and any consulting parties, as specified in 36 CFR 800.11(e). Currently, there are no federally recognized Native American Tribes associated with the location of the APE.

Conclusions

NASA has determined that the Arc Jet Complex, specifically Building N234, Building N238, and the SVS, meets NRHP Criterion A, retains integrity, and is eligible for listing in the NRHP, and that Building N242, the Structural Dynamics Laboratory, meets NRHP Criteria A and C, retains integrity, and is eligible for listing in the NRHP.

The Arc Jet Complex and Building N242 are historic properties within the APE that will be impacted by the undertaking. The significance of these historic properties is primarily associated with innovation in research and development related to experimentation for space flight conducted within the research facilities. The project proposes the removal of Building N234A and construction of Building N234B with a new boiler to meet the needs of the Arc Jet Complex. In its assessment of effects, NASA found that the proposed design of the new Building N234B boiler facility is compatible with adjacent historic properties and will not significantly diminish the integrity of the historic properties, thus meeting the Secretary of the Interior's Standards. NASA has determined that the undertaking's impact would not constitute an adverse effect due to its minimal impact on the ability of the adjacent historic properties to convey their historical associations that make them eligible for the NRHP. NASA, in applying the Criteria of Adverse Effect on the proposed project activities, proposes that a finding of no adverse effect is appropriate.

NASA is seeking the SHPO's concurrence with its determination that the Arc Jet Complex and Building N242 are historic properties eligible for listing in the NRHP. NASA is also seeking the SHPO's concurrence with NASA's finding that the proposed undertaking will have no adverse effect on historic properties. NASA requests the SHPO's concurrence within 30 days of receipt of this letter, as specified in 36 CFR 800.5(c).

Please contact me at keith.venter@nasa.gov or at (650) 604-6408 with your comments or questions.

Sincerely,

Keith Venter
Historic Preservation Officer

Ames Research Center

Ames Research Center, MS 213-8
Moffett Field, California 94035

cc:

HQ/EMD/Ms. Klein, Ph.D., RPA

Attachments

A. Project Location Map
B. APE Map
C. Site Plan
D. Architectural Plans
E. DPR 523 Series Forms

References

Advisory Council for Historic Preservation (ACHP)

1991 *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities.* Excerpts available online at http://www.achp.gov/balancingsum.html.

NASA

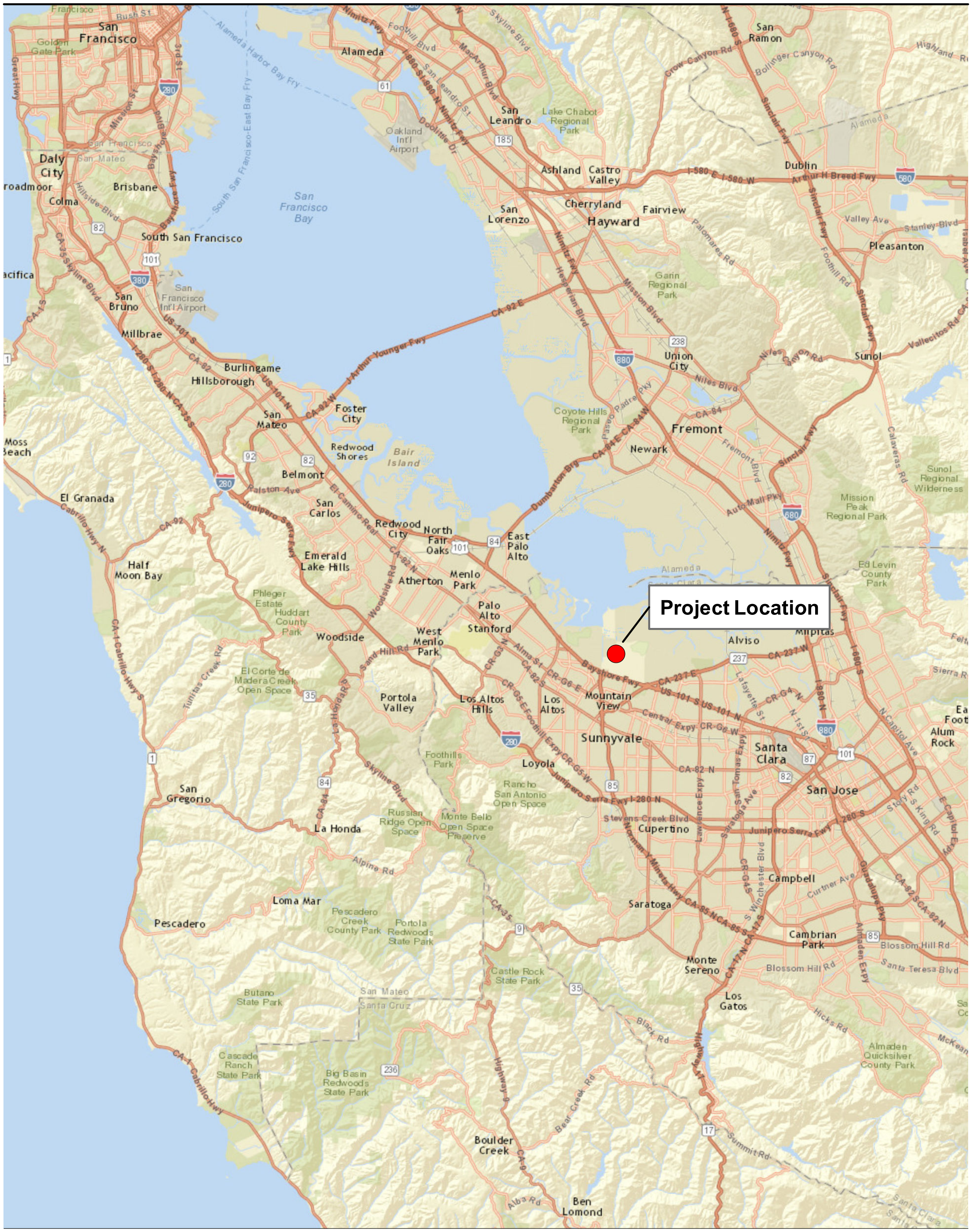
2006 *Evaluating Historic Resources Associated with the Space Shuttle Program: Criteria of Eligibility for Listing in the National Register of Historic Places (NRHP)*. Washington, D.C.: National Aeronautics and Space Administration.

Page & Turnbull

2007 *Space Shuttle Program: NASA Ames Research Center, Moffett Field, California.* Available online at ARC historic properties web site, http://historicproperties.arc.nasa.gov/shuttle.html.

ATTACHMENT A

PROJECT LOCATION MAP



Source: ESRI 2015

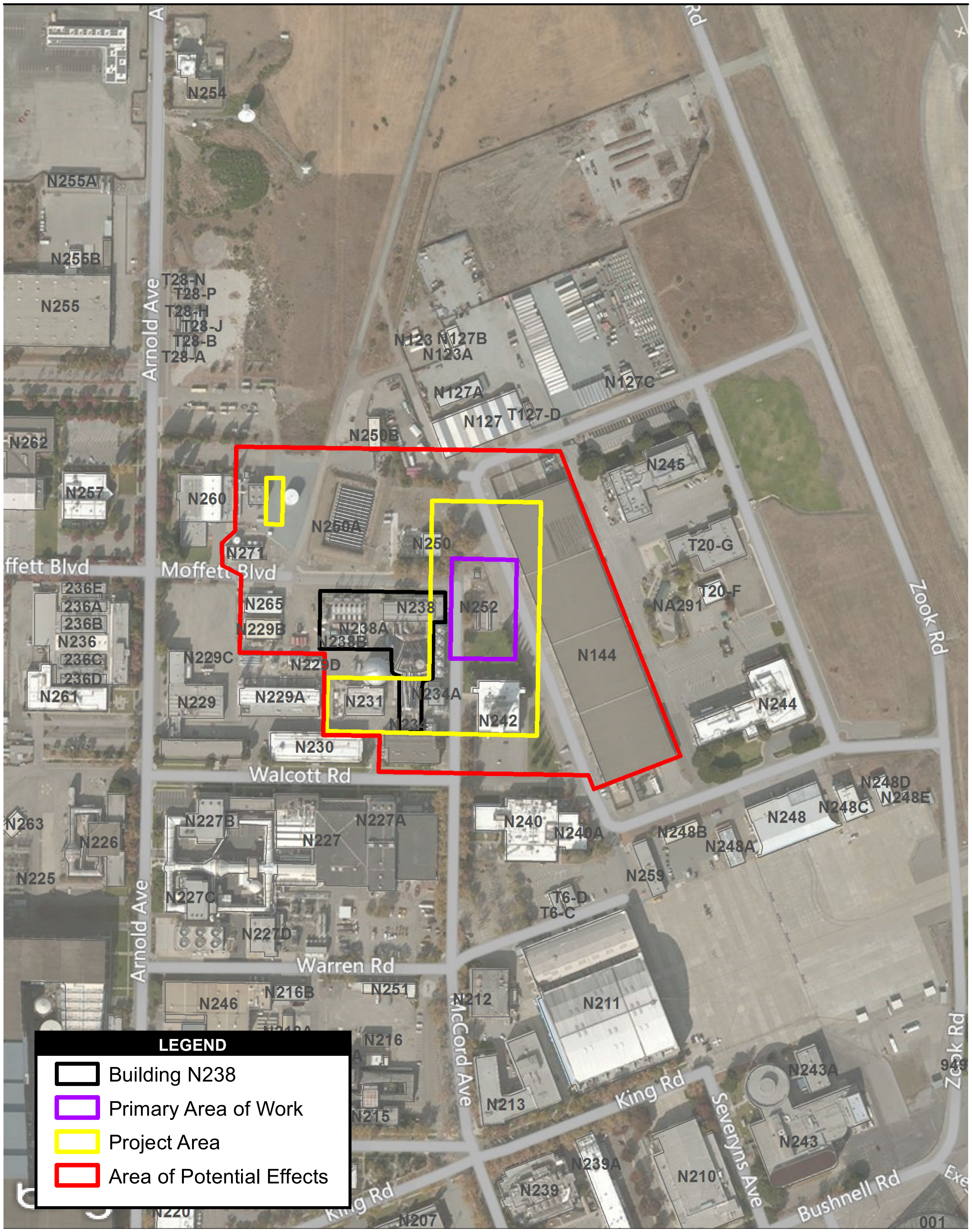
6 3 0 6 Miles

Scale: 1:380,160; 1 inch = 6 miles

Attachment A
Regional Map

ATTACHMENT B

APE MAP



Source: MIcrosoft 2015; ESRI 2015

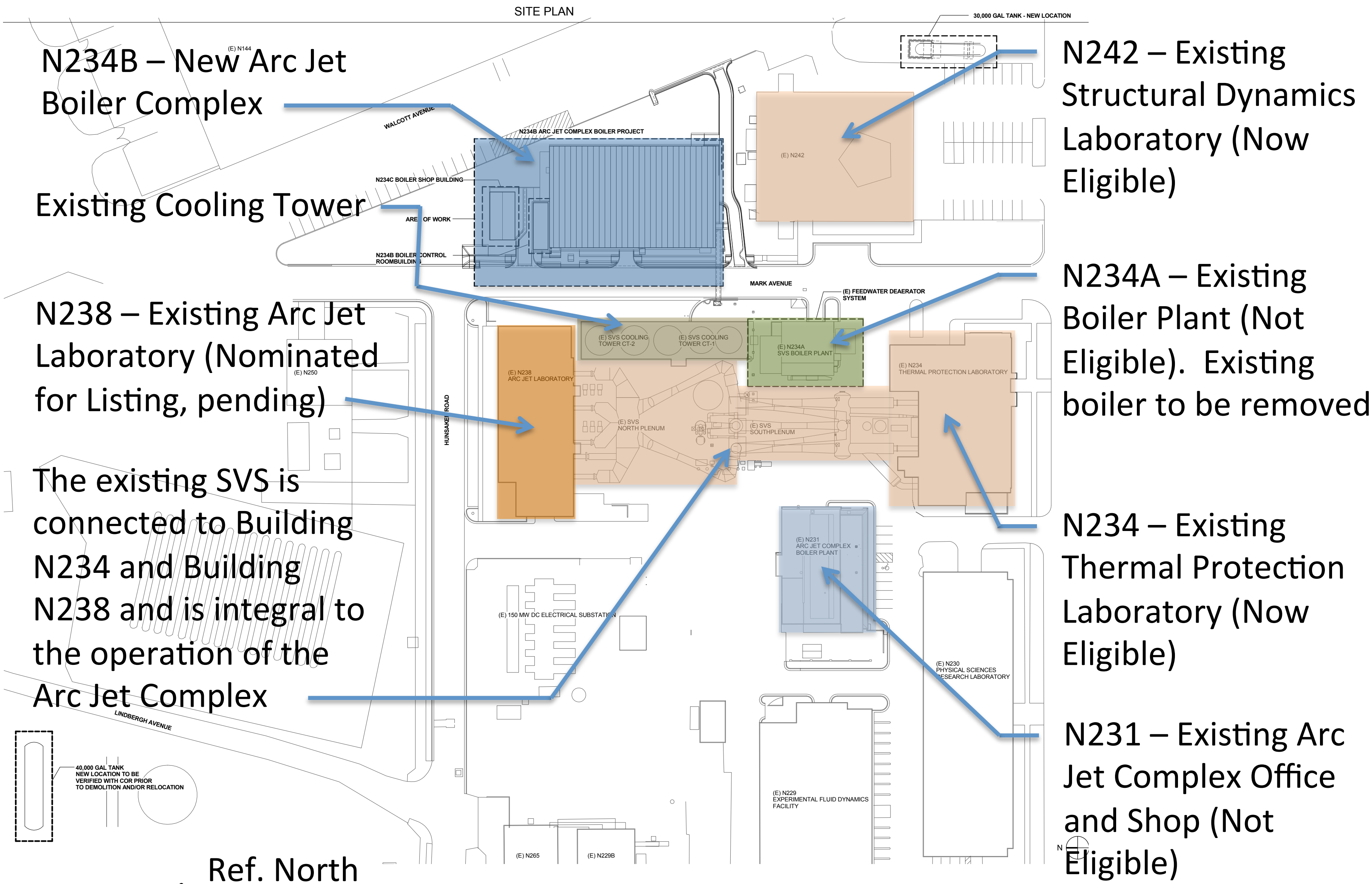
400 200 0 400 Feet

Scale: 1:4,800; 1 inch = 400 feet

Attachment B
Area of Potential Effects for the Arc Jet Complex SVS Boiler Replacement Project

ATTACHMENT C

SITE PLAN


SITE PLAN
N234B – New Arc Jet Boiler Complex
Existing Cooling Tower
N238 – Existing Arc Jet Laboratory (Nominated for Listing, pending)
The existing SVS is connected to Building N234 and Building N238 and is integral to the operation of the Arc Jet Complex
N242 – Existing Structural Dynamics Laboratory (Now Eligible)
N234A – Existing Boiler Plant (Not Eligible). Existing boiler to be removed
N234 – Existing Thermal Protection Laboratory (Now Eligible)
N231 – Existing Arc Jet Complex Office and Shop (Not Eligible)
Ref. North
30,000 GAL TANK - NEW LOCATION
N234B ARC JET COMPLEX BOILER PROJECT
N234C BOILER SHOP BUILDING
N234B BOILER CONTROL ROOMBUILDING
WALCOTT AVENUE
MARK AVENUE
(E) FEEDWATER DEAERATOR SYSTEM
HUNSAKER ROAD
(E) N242
(E) SVS COOLING TOWER CT-2
(E) SVS COOLING TOWER CT-1
(E) N234A SVS BOILER PLANT
(E) N234 THERMAL PROTECTION LABORATORY
(E) N238 ARC JET LABORATORY
(E) SVS NORTH PLENUM
(E) SVS SOUTHPLENUM
(E) N231 ARC JET COMPLEX BOILER PLANT
(E) 150 MW DC ELECTRICAL SUBSTATION
(E) N230 PHYSICAL SCIENCES RESEARCH LABORATORY
(E) N229 EXPERIMENTAL FLUID DYNAMICS FACILITY
(E) N265
(E) N229B
LINDBERGH AVENUE
40,000 GAL TANK NEW LOCATION TO BE VERIFIED WITH COR PRIOR TO DEMOLITION AND/OR RELOCATION

Site Plan

ATTACHMENT D

ARCHITECTURAL PLANS

The following content was redacted from this public posting:

Attachment D
Architectural Plans

ATTACHMENT E

DPR 523 SERIES FORMS

State of California — The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary #____________________
HRI # ____________________
Trinomial ____________________

*__Resource Name or #:__ Arc Jet Complex

P1. Other Identifier: Arc Jet Laboratory, Thermal Protection Laboratory, Building N234, Building N238
***P2. Location:** ☐ **Not for Publication** ☑ **Unrestricted** ***a. County:** Santa Clara
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5' Quad:** San Francisco North **Date:** 1995 **T** N/A; **R** N/A **¼ of¼ of Sec ; B.M.** S.B.B.M.
c. Address: 370 Boyd Road and 980 Mark Avenue City: Moffett Field Zip: 94035
d. UTM: Zone: ;
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate) Elevation:
Located at the Ames Research Center (ARC), along the west side of Mark Avenue between Boyd Road and Hunsaker Road.

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
The Arc Jet Complex is composed of Buildings N234, N234A, and N238, and the Steam Vacuum Sytem (SVS) that connects them.

Building N234 – Thermal Protection Laboratory (Gasdynamics Laboratory)
Constructed in 1962 as the Gasdynamics Laboratory, Building N234 is used for thermal protection materials research in heat shield applications for spacecraft reentry into Earth's atmosphere. Building N234 is a 24,670-square-foot, two-story laboratory and office building with a concrete foundation, an asymmetrical plan, and a flat roof. The building has two distinct parts: a portion on the south side (front) with offices and research support areas, and a portion on the north side (rear) with the test areas. The front of the building has concrete exterior walls that are scored in a grid pattern. Each story on the south side and east side contains a series of continuous aluminum-framed fixed windows some with hopper or awning sash and a flat concrete awning projecting over the windows. The offset central entrance contains a recessed pair of glazed doors with a transom and projecting concrete awning above, flanked by full-height brick pilasters. The west side contains no fenestration and has an attached brick partition wall enclosing the area around it. The rear portion of the building is clad with corrugated metal siding and has an L-shaped plan. The east side contains a single glazed door and a roll-up steel utility door in the first story, and an exterior staircase leading to a single glazed door in the second story. The rear of the building is connected to SVS equipment. (See Continuation Sheet.)

***P3b. Resource Attributes:** (List attributes and codes) HP39 – Other: Research laboratory

***P4. Resources Present:** ☑Building ☑Structure ☐Object ☐Site ☐District ☐Element of District ☐Other (Isolates, etc.)

P5a. Photo or Drawing (Photo required for buildings, structures, and objects.)

P5b. Description of Photo:
Building N234, south facade, view facing northwest, 07/23/2015.

***P6. Date Constructed/Age and Sources:** ☑Historic ☐Prehistoric ☐Both
1962-1965

***P7. Owner and Address:**
NASA Ames Research Center
Moffett Field, CA 94035

***P8. Recorded by:**
AECOM
401 W A Street
San Diego, CA 92101

***P9. Date Recorded:** 07/23/2015

***P10. Survey Type:** Intensive

***P11. Report Citation:** Section 106 Consultation on the Arc Jet Complex Steam Vacuum System Boiler Replacement and Relocation Project at Ames Research Center, Moffett Field, California, NASA, 2015

***Attachments:** ☐NONE ☐Location Map ☐Sketch Map ☑Continuation Sheet ☑Building, Structure, and Object Record ☐Archaeological Record ☐District Record ☐Linear Feature Record ☐Milling Station Record ☐Rock Art Record ☐Artifact Record ☐Photograph Record ☐ Other (List):

Primary #
HRI#

BUILDING, STRUCTURE, AND OBJECT RECORD

***NRHP Status Code** 2S2; 3S
***Resource Name or #** Arc Jet Complex

B1. Historic Name: Gasdynamics Laboratory, Mach 50 Helium Laboratory, Arc Jet Laboratory, Thermal Protection Laboratory
B2. Common Name: Arc Jet Complex, Building N234, Building N238, SVS, Building N234A
B3. Original Use: Research facility **B4. Present Use:** Research facility
***B5. Architectural Style:** Contemporary
***B6. Construction History:** (Construction date, alterations, and date of alterations)

The Arc Jet Complex was constructed as the Gasdynamics Laboratory (Building N234) from 1960-1962. At that time, the Steam Vacuum System (SVS), coolting towers, and boiler plant in Building N234A were also constructed. In 1965, the Mach 50 Helium Tunnel (Building N238) was added to the complex. While the research equipment within the complex has changed over time, including the removal of the Mach 50 Helium Tunnel and the introduction and removal of several arc jets, the buildings and the SVS have remained relatively unaltered.

***B7. Moved?** ☑No ☐Yes ☐Unknown **Date:** **Original Location:**
***B8. Related Features:** The Arc Jet Complex is composed of Buildings N234, N238, and the SVS equipment. Support features include the SVS cooling towers, the boiler plant (Buildings N234A), and various utility and storage facilities (N238A, N238B, and N238C).

B9a. Architect: Glen Goodwin and Dean Chapman, NASA
b. Builder: NASA (contractor)
***B10. Significance:** Scientific Research **Theme:** Research facility **Area:** Ames Research Center, Moffett Field
Period of Significance: 1962-2011 **Property Type:** Research facility **Applicable Criteria:** A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

The Arc Jet Complex, specifically Building N234, Building N238, and the SVS, meet NRHP Criterion A for its association with the creation and operation of the arc jets, its contributions to important scientific research related to space exploration, for a period of significance from 1962, the year that the Gasdynamics Laboratory was completed, to 2011, the end of the SSP and NASA-directed manned spaceflight. The Arc Jet Complex retains integrity of location, design, setting, materials, workmanship, feeling, and association, and is eligible for the NRHP.

See Continuation Sheet.

B11. Additional Resource Attributes: (List attributes and codes)

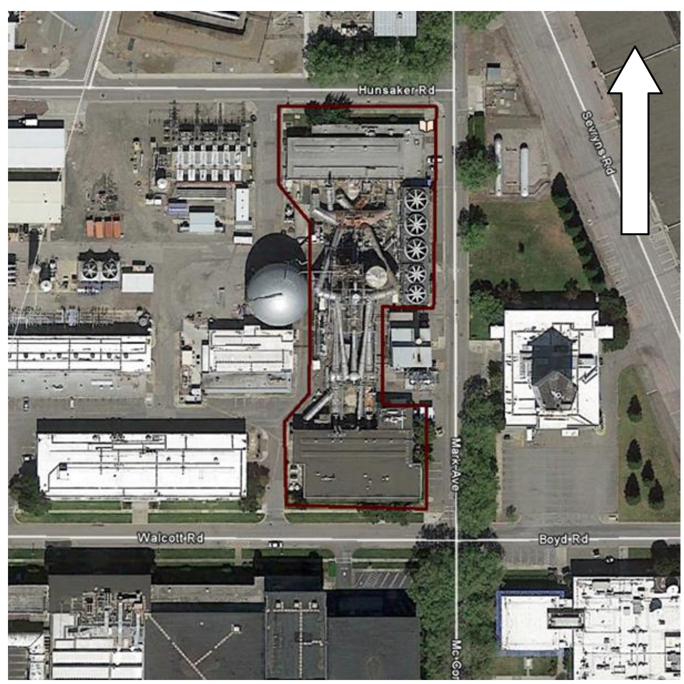
***B12. References:**
See Continuation Sheet.

B13. Remarks:

***B14. Evaluator:** M.K. Meiser, M.A., AECOM

***Date of Evaluation:** 07/23/2015

(This space reserved for official comments.)



***P3a. Description:** (continued)

Building N238 – Arc Jet Laboratory (Mach 50 Helium Tunnel)
Built in 1964 as the Mach 50 Helium Tunnel, Building N238 has a utilitarian design composed of two distinct sections: a one-story L-shaped portion with brick exterior walls (containing the control room), and a corrugated metal structure one and one-half stories high (test area) situated within the ell of the brick portion and extending to the south and west (**Photograph 1**). The building has a 17,030-square-foot rectangular plan with a concrete foundation, a steel-frame structural system, and a flat roof. The façade (north elevation) of the brick portion contains two windows in the eastern portion and an entrance with glazed double-doors in the western portion. The east side of the brick portion extends the full width of the building and contains a steel overhead utility door. The west side of the brick portion and the north side of the corrugated metal portion have no fenestration. The west side of the corrugated metal portion contains a steel overhead utility door and a single man-door. The rear (south elevation) of Building N238 is connected to the SVS. The building's interior at one time contained five discrete test bays: the 60-megawatt Interaction Heating Facility, the Direct Connect Facility; the Panel Test Facility; the Giant Planet Facility; and the High Enthalpy Facility.

Photograph 1. Building N238, view facing southeast.

SVS
The SVS (**Photograph 2**) is a highly specialized steam vacuum system composed of metal plenums, tubes, valves, structural supports, tanks, and cooling towers. The SVS connects Building N234 and Building N238 and is integral to the operation of the Arc Jet Complex. The cooling towers that support the SVS consist of five aligned cylindrical towers with vents housed in a rectangular, two-story structure that is clad in corrugated metal and vented in the first story (**Photograph 3**).

Photograph 2. SVS, view facing northeast.

Photograph 3. SVS cooling towers, view facing northwest.

Building N234A – Boiler/ SVS Vacuum Ejector and Boiler Control System

Building N234A is a three-story building with a concrete foundation, a steel-frame structural system, and a dual shed roof (**Photograph 4**). The roof is covered with corrugated metal, and several vents and a large cylindrical pipe project from it. The exterior is clad with corrugated metal siding. On the east and west sides of the building, each story contains a series of steel-sash, industrial windows with operable awning window panels in the center. The east side also contains a roll-up steel utility door that has been modified to contain a single glazed steel door. The west side of the building has an exterior staircase attached that leads to a single steel door in the second story and pipes that extend from the building to connect to the SVS. The south side contains a single glazed steel door and is connected to an adjacent three-story structure that holds a series of tanks. The north side of Building N234A has a one-story shed addition and a vent in the second story.

Photograph 4. Building N234A, east side, view facing southwest.

***B10. Significance:** (continued)

When the National Aeronautics and Space Administration (NASA) was formed in 1958, its primary goals were manned spaceflight and a lunar landing as part of the space race with the Soviet Union after the launch of *Sputnik* in 1957. Ames Research Center (ARC), formerly the National Advisory Committee for Aeronautics (NACA) Ames Aeronautical Laboratory, refocused its energies and resources to the new, space mission-oriented projects, including the goal of landing a man on the moon by the end of the 1960s. NASA's projects received higher budgets and new facilities to accomplish these goals. In addition to its established research in aeronautics, ARC added divisions dedicated to space-related research, including life sciences, flight simulation, and thermal protection.

In 1953, Ames theorist Harvey Allen published his seminal work on the blunt-body concept for ballistics reentry into the Earth's atmosphere, which also would enable the safe reentry of spacecraft (Vincenti, et al. 2007:1). To test the blunt-body theory, Ames researchers began developing ways to simulate the conditions of reentry. Beginning in 1956, Ames began addressing the need to reproduce the extreme heat that space vehicles would encounter upon reentry to the Earth's atmosphere. NASA instructed ARC to focus on testing the thermal and aerodynamic facets of Harvey Allen's blunt-body theory. In 1959, ARC reorganized its two high-speed, space-related divisions under Allen's direction. The Aero-Thermodynamics Division included several branches: the Supersonic Free-Flight Wind Tunnel Branch; the Heat Transfer Branch; the Fluid Mechanics Branch; and the Transonic Aerodynamics Branch. The Vehicle Environment Division included the Physics Branch; Entry Simulation Branch; Structural Dynamics Branch; the 3.5-foot Hypersonic Wind Tunnel Branch; and the Hypervelocity Ballistic Range Branch.

In the early 1960s, ARC had a "frantic spurt of building," more than doubling the value of its research facilities from 1958 to 1965 (Muenger 1985:129). Facilities that could simulate reentry conditions of space vehicles were predominant during this early period of ARC. By 1962, almost half of the research conducted at ARC was dedicated to entry and environmental physics, and new facilities paralleled these new research directions (Muenger 1985:128-129). New facilities dating to the early 1960s included the Hypervelocity Research Laboratory (Building N230), 3.5-foot Hypersonic Tunnel (Building N229), the 20-inch Hypersonic Helium Tunnel (Building N231), the 1-foot Hypervelocity Shock Tunnel, the Mach 50 Helium Tunnel (Building N238), the Hypervelocity Free-Flight Facility, the Impact Range, and the Gasdynamics Laboratory (Building N234).

Arc jets, or arc jet tunnels, are electric arc apparatuses that heat pressurized gases to very high temperatures and project them through supersonic or hypersonic nozzles to flow over test sections, thus simulating the temperature, pressure, and enthalpy experienced by a space vehicle upon reentry. Interest in arc jets increased rapidly under NASA, and ARC's scientists work to rapidly refine arc jets was "a major contribution to both arc-jet technology and to aerothermodynamic research" (Hartman 1970:336). In 1960, work on small and experimental arc jets was adequately refined to be useful in reentry research, and NASA approved the construction of a major $4 million facility for testing heating processes (Hartman 1970:339). Construction on the Gasdynamics Laboratory (Building N234) began in 1960 and finished in 1962.

Designed by Ames aerodynamic heating researchers, Glen Goodwin and Dean Chapman, the new facility had operational flexibility intended for the further development of arc jets, with 10 eventual test bays (five in Building N234 and five in Building N238), a massive air handling evacuator and collector (SVS), and a 15-megawatt electrical power supply (Hartman 1970:339). The facility enabled arc jet and thermal protection research focused on ablation and the aerodynamic characteristics of reentry bodies, and the refinement of arc jets themselves.

In 1964, the complex was expanded to its present form with the addition of the Mach 50 Helium Tunnel (Building N238) (**Figure 1**). Opened in 1965, the Mach 50 Helium Tunnel cost $1.5 million and was intended for testing larger models for longer intervals (Hartman 1970:414). ARC had other lower-speed helium wind tunnels when the Mach 50 Helium Tunnel was built, but by 1965, interest in helium tunnels waned because the usefulness of helium for simulating the aerothermodynamic environment of high-speed reentry was in doubt (Hartman 1970:415). The tunnel required a surge of electric arc power produced by a bank of capacitors equivalent to over 10 million horsepower to heat the helium (Hartman 1970:422). The new facility generated high airspeeds, but did not create a stable enough environment for practical testing. The Mach 50 Helium Tunnel was eventually retired and more arc jets were installed in the test bays in the Mach 60 Helium Tunnel facility.

By the end of 1965, ARC had a dozen arc jets, with two in Building N234 and one in Building N238 (Bugos 2000:65). In 1964, ARC engineers Howard A. Stine, Charles E. Shepard, and Velvin R. Watson, patented a high-enthalpy constricted-arc heater developed in the laboratory, a "high temperature wind tunnel in which the heat is provided by an electric arc" (U.S. Patent Office 1968). In Building 238, the 1-inch Constricted-Arc Supersonic Jet was the most sophisticated and highest performance of all ARC arc jets (Hartman 1970:422). It achieved Mach 3, enthalpies up to 200,000 Btu per pound, using any mixture of gas (air, nitrogen, and carbon dioxide), and was used to test ablative materials for heat shields (Hartman 1970:422; Bugos 2000:65). The arc jet design enabled the development of Thermal Protection Systems (TPS) materials for Mercury and Apollo missions, and it still serves as the basic design for all high-powered arc jets. By the late 1960s, nine arc jet test bays, including the 60-megawatt Interaction Heating Facility (in Building N238) were operational at the Arc Jet Complex (**Photograph 5**).

The 60-megawatt Interaction Heating Facility began operation in 1973 to test reusable TPS for the space shuttles. It was one of the highest-power arc jets ever constructed, and could test larger samples in both a stagnation and flat plate configuration (Page & Turnbull 2007:38). In 1975, Howard K. Larson, chief of the Ames Thermal Protection Branch, stated that ARC had NASA's largest collection of arc- or plasma-heated facilities with three of its major units dedicated to shuttle support, including the 60-megawatt Interaction Heating Facility that was "probably the highest-powered unit operating in the U. S." (Page & Turnbull 2007:38). The capability of the facility to test a 2-foot by 2-foot section of TPS tile in conditions duplicating aeroconvective heating and reacting boundary layer chemistry during simulated entry conditions was a crucial element in the development of the space shuttle (Page & Turnbull 2007:39).

ARC scientists developed concepts on the properties of TPS and produced TPS prototypes tested in the Arc Jet Laboratory. As a result of testing with arc jets, ARC scientists developed the TPS technology for the space shuttles, including materials known as LI-2200, FRCI, RCG, TUFI, and the Ames Gap Fillers (Page & Turnbull 2007:39). ARC was involved in the development of TPS for every NASA space program, including Apollo, Space Shuttle, Viking, Pioneer-Venus, Galileo, Mars Pathfinder, MER heatshield, Stardust, NASP, X-33, X-34, SHARP-B1 and B2, X-37 WLE TPS and most recently CEV/Orion heatshield development and Mars Science Laboratory TPS (nasa.gov).

Currently, the Arc Jet Complex, directed by the Thermophysics Facilities Branch, has seven available test bays and four bays containing the Interaction Heating Facility, the Panel Test Facility, the Turbulent Flow Duct, and the Aerodynamic Heating Facility. The test bays are supported by common equipment, including two D.C. power supplies, a steam ejector-driven vacuum system, a water-cooling system, high-pressure gas systems, data acquisition systems, and other auxiliary systems (nasa.gov). The facility remains critical for TPS thermal models, designs, and flight qualification (nasa.gov).

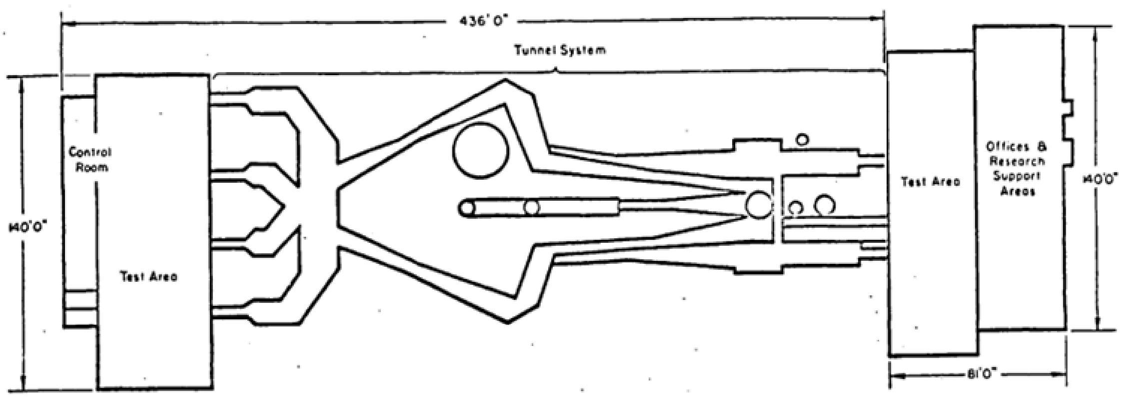


Figure 1. The Mach 50 Helium Tunnel (Building N238, at left) and the Gasdynamics Laboratory (Building N234, at right), 1967 (ARC 1967).

Photograph 5. Aerial view of the Arc Jet Complex, circa 1974, view facing southwest (Building N238 in foreground, SVS at center, Building N234 at top).

Evaluation and Significance:

NRHP Criterion A

Building N238 has been previously determined eligible for listing in the NRHP under Criterion A at the national level of significance for its association with NASA's Space Shuttle Program (SSP), specifically for the research and development of Thermal Protection Systems (TPS) for the space shuttle conducted in its 60-megawatt Interaction Heating Facility. The 60-megawatt Interaction Heating Facility was one of, if not the highest-powered arc jets in the U.S. with the capacity to test larger TPS materials for extended periods. The contributions of this scientific research and the development of the TPS technology were integral to the successful operation of vehicles in the SSP by enabling reentry for the space shuttle orbiters, being the only facility to test TPS for the SSP. The 60-megawatt Interaction Heating Facility is also important for its technological capability of simulating atmospheric entry heating conditions three times hotter and on larger models than any other arc jet (Bugos 2003:8; Page & Turnbull 2007:41). For this association, Building N238 was determined eligible for the National Register of Historic Places under Criterion A with a period of significance from 1973, the year it was completed, to 2011, the end of the SSP (Page & Turnbull 2007:41). The property also met Criteria Consideration G for properties that have achieved significance within the past 50 years, due to its exceptional significance within the context of the SSP. The significance of Building N238 was measured according to NASA's guidelines published in *Evaluating Historic Resources Associated with the Space Shuttle Program: Criteria of Eligibility for Listing in the National Register of Historic Places (NRHP)* (NASA 2006). Building N238 was determined eligible in 2007 (Page & Turnbull 2007), and has been nominated for the NRHP (pending November 2015).

Constructed in 1962 and 1965, the Arc Jet Complex, specifically Building N234 (formerly Gasdynamics Laboratory, now Thermal Protection Laboratory), the SVS, and Building N238 (formerly Mach 50 Helium Tunnel, now Arc Jet Laboratory), is associated with scientific innovation and the development of arc jet technology. The arc jet technology designed and built in the complex contributed to the successful development of TPS technology related to NASA's mission to achieve manned spaceflight and a lunar landing in the 1960s. TPS technology was critical for the successful reentry of spacecraft related to every NASA space program, including Apollo, Space Shuttle, Viking, Pioneer-Venus, Galileo, Mars Pathfinder, MER heatshield, Stardust, NASP, X-33, X-34, SHARP-B1 and B2, X-37 WLE TPS and most recently CEV/Orion heatshield development and Mars Science Laboratory TPS. The unique invention of high-powered arc jets that approximately simulated the conditions upon entry into the Earth's atmosphere to develop TPS technology originated in the test areas of the Arc Jet Complex.

The Arc Jet Complex is eligible for the NRHP under Criterion A for its association with the creation and operation of the arc jets, its contributions to important TPS research related to space exploration, for a period of significance from 1962, the year that the Gasdynamics Laboratory was completed, to 2011, the end of the SSP and NASA-directed manned spaceflight. Building N234, the SVS, and Building N238 are the primary features of the Arc Jet Complex that meet this criterion.

Building N234A (the SVS boiler) was recycled from the *U.S.S. Helena*, a Navy Baltimore-class ship built in 1945 that was decommissioned after the war. The boiler was built by the Babcock & Wilcox Co. in Barberton, Ohio, in 1944. It is uncertain how the boiler was acquired. The boiler inside of Building N234A has supported the SVS since it was constructed as part of the Gasdynamics Laboratory in 1962, but is an auxiliary feature of the complex and is not directly related to the significant scientific research related to arc jets and space exploration that has taken place within the laboratories. The boiler itself was built for a Navy ship, the 1945 U.S.S. Helena, and repurposed for the laboratory. Building N234A (SVS boiler), although dating to the period of significance, is a secondary feature of the Arc Jet Complex, and does not achieve a level of significance to meet NRHP Criterion A.

NRHP Criterion B

The Arc Jet Complex is associated with several scientists and researchers who had long and productive careers at ARC, and who contributed to science. Glen Goodwin and Dean Chapman were instrumental in designing and developing the facility, and Howard A. Stine, Charles E. Shepard, and Velvin R. Watson were important for advancing arc jet technology through experimentation in the arc jet laboratories. However, the Arc Jet Complex facility is not significantly associated to a single important historic individual as a representation of that individual's career or historical contributions. It does not meet NRHP Criterion B.

NRHP Criterion C

The unique design of the Arc Jet Complex represents a highly specialized research facility, with two laboratory buildings connected by the massive SVS. While this design enabled the development, design, and operation of the arc jet technology that significantly contributed to important scientific research related to space exploration, the facility does not embody distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values. Building N234 is a Modern, reinforced concrete office building with some architectural features of note, including scored concrete exterior walls, horizontality emphasized by flat concrete awnings and continuous windows, and its offset, two-story entrance block. Building N238 also has a Modern design, with low horizontality in its otherwise undistinctive brick facade. The SVS is a massive structure with industrial grade components that were designed on existing engineering principles for wind tunnels and vacuum systems. These components lack individual distinction, and as a whole, the Arc Jet Complex is not a distinguishable entity that meets the level of significance to meet NRHP Criterion C.

NRHP Criterion D

Information related to the design and development of the Arc Jet Complex, first as the Gasdynamics Laboratory and the Mach 50 Helium Tunnel, is well documented. The Arc Jet Complex does not, and is not likely to yield information regarding history or prehistory. Therefore, the property does not meet NRHP Criterion D.

<u>Integrity Analysis:</u>

Location

The Arc Jet Complex remains in its original location at ARC.

Design

The Arc Jet Complex has been minimally altered since it was built between 1962 and 1964. The exterior design of Buildings N234 and N238 and the form of the SVS are intact.

Setting

The Arc Jet Complex is located on the ARC campus, surrounded by other highly specialized research facilities of varying design and massing. No new major facilities in its immediate vicinity have been built since 1974 (Buildings N242, N250), although smaller industrial storage and utility auxiliary facilities were built in the 1990s and 2000s (Buildings N238A-C). Overall, the Arc jet Complex retains integrity of setting.

Materials

The Arc Jet Complex has been minimally altered since it was built between 1962 and 1964. The brick, metal, and concrete materials of Buildings N234 and N238 and the metal structure of the SVS are intact.

Workmanship

The workmanship evident in the Arc Jet Complex has not been altered; the resource retains integrity of workmanship.

Feeling

Because the Arc Jet Complex retains its design, setting, and association as a highly specialized research facility on the ARC campus, and is still used for arc jet research, it retains integrity of feeling.

Association

The Arc Jet Complex is associated with important TPS research and with arc jet technology innovation at ARC. This association is evident in its continued use to the present day; the resource retains integrity of association.

<u>Summary:</u>

The Arc Jet Complex, specifically Building N234, Building N238, and the SVS, meet NRHP Criterion A for its association with the creation and operation of the arc jets, its contributions to important scientific research related to space exploration, for a period of significance from 1962, the year that the Gasdynamics Laboratory was completed, to 2011, the end of the SSP and NASA-directed manned spaceflight. The Arc Jet Complex retains integrity of location, design, setting, materials, workmanship, feeling, and association, and is eligible for the NRHP.

References:

ARC

1967 *Technical Facilities Capability Catalog*. On file at ARC.

Bugos, Glenn E.

2000 *Atmosphere of Freedom: Sixty Years at the NASA Ames Research Center*. Washington, D.C.: National Aeronautics and Space Administration Special Publication-4314, 2000.

Hartman, Edwin
1970 *Adventures in Research: A History of Ames Research Center, 1940-1965*. NASA.

Muenger, Elizabeth A.
1985 *Searching the Horizon: A History of Ames Research Center, 1940-1976*. NASA.

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n.d. "Arc Jet Complex." Available at: http://www.nasa.gov/centers/ames/thermophysics-facilities/arcjet-complex.

Page & Turnbull, Inc.
2007 *Assessment: Space Shuttle Program, NASA Ames Research Center, Moffett Field, CA.* Prepared for NASA Ames Research Center, Moffett Field. San Francisco, CA.

U.S. Patent Office
1968 *Electric Arc Apparatus*. Patent No. 3,360,988. Granted to Howard A. Stine, Charles E. Shepard, and Velvin R. Watson.

Vincenti, Walter G., John W. Boyd, and Glenn E. Bugos
2007 "H. Julian Allen: An Appreciation," *Annual Review of Fluid Mechanics* 39 2007:1–17.

State of California — The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary #______________________
HRI # ______________________
Trinomial ______________________

*__Resource Name or #:__ Building N144 - Warehouse

P1. Other Identifier: FEMA Warehouse
***P2. Location:** ☐ **Not for Publication** ☑ **Unrestricted** ***a. County:** Santa Clara
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5' Quad:** San Francisco North **Date:** 1995 **T** N/A; **R** N/A **¼ of¼ of Sec ; B.M.** S.B.B.M.
c. Address: Walcott Avenue City: Moffett Field Zip: 94035
d. UTM: Zone: ;
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate) Elevation:
The resource is located at the NASA Ames Research Center, bounded by Walcott Avenue, Pollack Road, H Lane, and Hall Road.

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

Building N144 is a warehouse located along the east side of Walcott Avenue, to the east of the Project Area and the Arc Jet Complex. The warehouse is one-story, with a concrete slab foundation, steel-frame structural system, corrugated cement-asbestos siding, and a low-pitched gable roof. It is 20 bays long with concrete firewalls between every five bays, and two bays wide. The bays contain regularly spaced access openings, primarily containing roll-up steel utility doors. There are also some glazed doors and metal sliding windows. The majority of roll-up steel utility doors are located on the west side facing Walcott Avenue. Building N144 has had some minor changes, including the addition of new access openings and the replacement of utility doors, but does not appear to have had any major alterations.

***P3b. Resource Attributes:** (List attributes and codes) HP39 – Other: Research laboratory

***P4. Resources Present:** ☑Building ☐Structure ☐Object ☐Site ☐District ☐Element of District ☐Other (Isolates, etc.)

P5a. Photo or Drawing (Photo required for buildings, structures, and objects.)

P5b. Description of Photo: Building N144, view facing north, 7/23/2015.

***P6. Date Constructed/Age and Sources:** ☑Historic ☐Prehistoric ☐Both
1952

***P7. Owner and Address:**
NASA Ames Research Center
Moffett Field, CA 94035

***P8. Recorded by:**
AECOM
401 W A Street
San Diego, CA 92101

***P9. Date Recorded:** 7/23/2015

***P10. Survey Type:** Intensive

***P11. Report Citation:** Section 106 Consultation on the Arc Jet Complex Steam Vacuum System Boiler Replacement and Relocation Project at Ames Research Center, Moffett Field, California, NASA, 2015

***Attachments:** ☐NONE ☐Location Map ☐Sketch Map ☐Continuation Sheet ☑Building, Structure, and Object Record ☐Archaeological Record ☐District Record ☐Linear Feature Record ☐Milling Station Record ☐Rock Art Record ☐Artifact Record ☐Photograph Record ☐ Other (List):

BUILDING, STRUCTURE, AND OBJECT RECORD

***NRHP Status Code** 6Z
***Resource Name or #** Building 144 – Warehouse

B1. Historic Name: General Warehouse
B2. Common Name: FEMA Warehouse
B3. Original Use: Warehouse **B4. Present Use:** Warehouse
***B5. Architectural Style:** Utilitarian
***B6. Construction History:** (Construction date, alterations, and date of alterations)
Built in 1952, Building N144 has continuously served a support function as a warehouse, and has had few alterations. Window and door opening replacements and alterations have minimally changed the building.

***B7. Moved?** ☑**No** ☐**Yes** ☐**Unknown** **Date:** **Original Location:**
***B8. Related Features:** None.

B9a. Architect: National Advisory Committee for Aeronautics (NACA)
b. Builder: National Advisory Committee for Aeronautics (NACA)
***B10. Significance:** Scientific Research **Theme:** Aerodynamics **Area:** Ames Research Center, Moffett Field
Period of Significance: 1952 **Property Type:** Warehouse **Applicable Criteria:** N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

Building N144 was previously evaluated not eligible for the NRHP due to a lack of architectural or historical significance (Page & Turnbull 2006). The warehouse was revisited, and does not appear to have had any major alterations. The warehouse is associated with a transitional period in aerodynamic research at Ames under the NACA, but does not represent any particular associations with significant research, historical themes, events, or individuals. Constructed of typical materials with a common design, it does not exhibit any significant architectural qualities. It does not meet NRHP Critera A-D, and is not eligible for the NRHP.

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:**

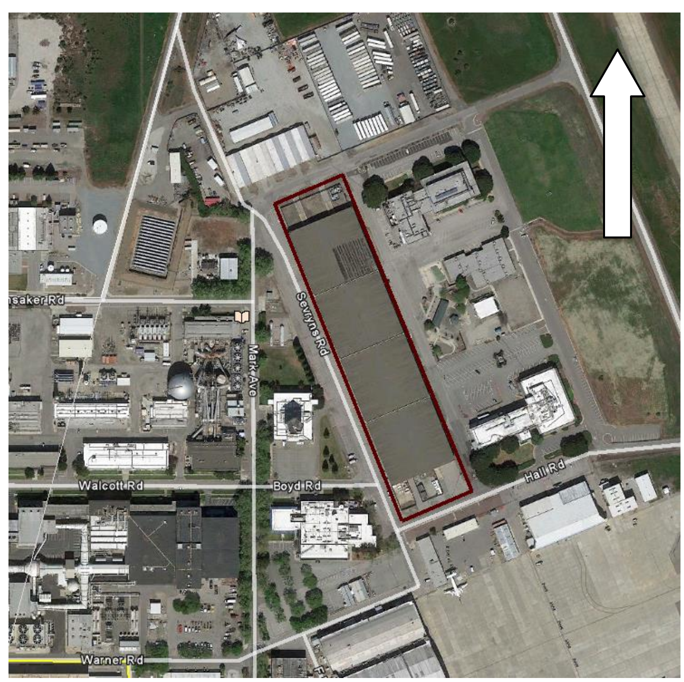
Page & Turnbull
2006 *NASA Ames Research Center, Moffett Field, California, Survey & Rehabilitation Recommendations*. On file at NASA Ames Research Center.

B13. Remarks:

***B14. Evaluator:** M.K. Meiser, M.A., AECOM

***Date of Evaluation:** 7/23/2015

(This space reserved for official comments.)



State of California — The Resources Agency **DEPARTMENT OF PARKS AND RECREATION** **PRIMARY RECORD**	Primary # HRI # Trinomial

 *__Resource Name or #:__ Building N231 - Hypersonic Helium Tunnel

P1. Other Identifier: Fluid Dynamics Laboratory, Arc Jet Complex Shop
***P2. Location:** ☐ **Not for Publication** ☑ **Unrestricted** ***a. County:** Santa Clara
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5' Quad:** San Francisco North **Date:** 1995 **T** N/A; **R** N/A **¼ of¼ of Sec ; B.M.** S.B.B.M.
c. Address: 360 Boyd Road City: Moffett Field Zip: 94035
d. UTM: Zone: ;
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate) Elevation:
The resource is located at the NASA Ames Research Center, setback from Boyd Road, between Buildings N230 and N234.

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

Building N231 is one-story, 7,400 sq. ft. building with a steel-frame structural system, concrete foundation, and a flat roof. The building has a roughly rectangular plan with two distinct parts: an office area on the south (front) side; and a testing area/warehouse on the north (rear) side. The front of the building has brick siding and a hipped canopy covered with standing seam sheet metal and supported by plain posts along the south and east sides. Inset under the canopy, the exterior walls contain a series of aluminum-framed fixed windows. The offset central entrance contains a recessed pair of glazed doors with a transom above, flanked by brick piers. The rear portion of the building is a half story taller, and is clad with corrugated metal siding and stucco or concrete siding. The east and west sides each contain a roll-up steel utility door and a single door. The north side of the building is attached to an evacuated helium spherical recovery tank and other equipment. Other equipment is located to the west of the building behind a brick partition wall.

***P3b. Resource Attributes:** (List attributes and codes) HP39 – Other: Research laboratory

***P4. Resources Present:** ☑Building ☑Structure ☐Object ☐Site ☐District ☐Element of District ☐Other (Isolates, etc.)

P5a. Photo or Drawing (Photo required for buildings, structures, and objects.)

P5b. Description of Photo: Building N231, south facade, view facing northwest, 7/23/2015.

***P6. Date Constructed/Age and Sources:** ☑Historic ☐Prehistoric ☐Both
1960

***P7. Owner and Address:**
NASA Ames Research Center
Moffett Field, CA 94035

***P8. Recorded by:**
AECOM
401 W A Street
San Diego, CA 92101

***P9. Date Recorded:** 7/23/2015

***P10. Survey Type:** Intensive

***P11. Report Citation:** Section 106 Consultation on the Arc Jet Complex Steam Vacuum System Boiler Replacement and Relocation Project at Ames Research Center, Moffett Field, California, NASA, 2015

***Attachments:** ☐NONE ☐Location Map ☐Sketch Map ☑Continuation Sheet ☑Building, Structure, and Object Record ☐Archaeological Record ☐District Record ☐Linear Feature Record ☐Milling Station Record ☐Rock Art Record ☐Artifact Record ☐Photograph Record ☐ Other (List):

BUILDING, STRUCTURE, AND OBJECT RECORD

 ***NRHP Status Code** 6Z

***Resource Name or #** Building N231 - Hypersonic Helium Tunnel

B1. Historic Name: Hypersonic Helium Tunnel

B2. Common Name: Building N231, Arc Jet Complex Shop

B3. Original Use: Research facility **B4. Present Use:** Offices and shop

***B5. Architectural Style:** Contemporary

***B6. Construction History:** (Construction date, alterations, and date of alterations)

Built in 1960 as the 20-inch Hypersonic Helium Tunnel facility, Building N231 has undergone substantial alteration. Originally connected to two helium spherical recovery tanks and other research equipment that comprised the 20-inch Hypersonic Helium Tunnel, the building no longer serves that function since the helium tunnel was dismantled and one helium spherical recovery tank (west side) was removed. An addition to the north side of the building doubled the size of the rear portion of the building, and utility doors were installed at an undetermined date. Currently, the building is used for offices and a shop related to the Arc Jet Complex.

***B7. Moved?** ☑**No** ☐**Yes** ☐**Unknown** **Date:** **Original Location:**

***B8. Related Features:** Building N231 is adjacent to a related helium spherical recovery tank and the Arc Jet Complex (Buildings N234, N238, and steam vacuum system equipment).

B9a. Architect: NASA

b. Builder: NASA

***B10. Significance:** Scientific Research **Theme:** Research facility **Area:** Ames Research Center, Moffett Field

Period of Significance: 1960 **Property Type:** Research facility **Applicable Criteria:** A

(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

While significant under NRHP Criterion A for its associations with important hypersonic scientific research and its contributions to science when it was the Hypersonic Helium Tunnel, Building N231 does not retain sufficient integrity to be listed in the NRHP.

See Continuation Sheet.

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:**

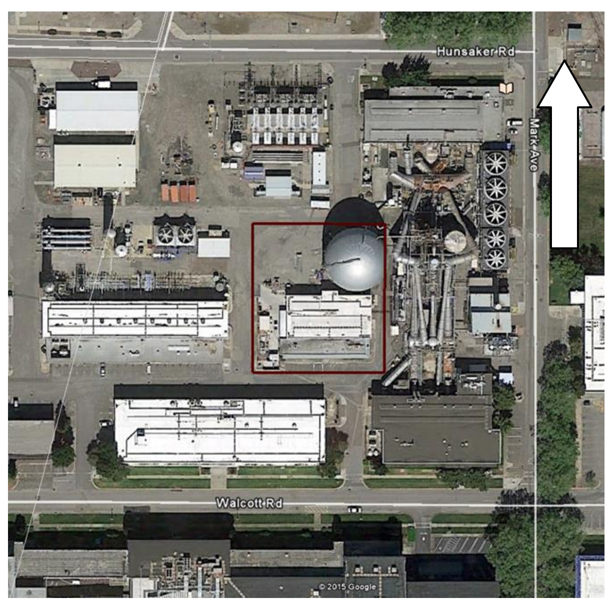
See Continuation Sheet.

B13. Remarks:

***B14. Evaluator:** M.K. Meiser, M.A., AECOM

***Date of Evaluation:** 7/23/2015

(This space reserved for official comments.)



***B10. Significance:** (continued)

When the National Aeronautics and Space Administration (NASA) was formed in 1958, its primary goals were manned spaceflight and a lunar landing as part of the space race with the Soviet Union after the launch of *Sputnik* in 1957. Ames Research Center (ARC), formerly the National Advisory Committee for Aeronautics (NACA) Ames Aeronautical Laboratory, refocused its energies and resources to the new, space mission-oriented projects, including the goal of landing a man on the moon by the end of the 1960s. NASA's projects received higher budgets and new facilities to accomplish these goals. In addition to its established research in aeronautics, ARC added divisions dedicated to space-related research, including life sciences, flight simulation, and thermal protection.

In 1953, Ames theorist Harvey Allen published his seminal work on the blunt-body concept for ballistics reentry into the Earth's atmosphere, which also would enable the safe reentry of spacecraft (Vincenti, et al. 2007:1). To test the blunt-body theory, Ames researchers began developing ways to simulate the conditions of reentry. Beginning in 1956, Ames began addressing the need to reproduce the extreme heat that space vehicles would encounter upon reentry to the Earth's atmosphere. NASA instructed ARC to focus on testing the thermal and aerodynamic facets of Harvey Allen's blunt-body theory. In 1959, ARC reorganized its two high-speed, space-related divisions under Allen's direction. The Aero-Thermodynamics Division included several branches: the Supersonic Free-Flight Wind Tunnel Branch; the Heat Transfer Branch; the Fluid Mechanics Branch; and the Transonic Aerodynamics Branch. The Vehicle Environment Division included the Physics Branch; Entry Simulation Branch; Structural Dynamics Branch; the 3.5-foot Hypersonic Wind Tunnel Branch; and the Hypervelocity Ballistic Range Branch.

In the early 1960s, ARC had a "frantic spurt of building," more than doubling the value of its research facilities from 1958 to 1965 (Muenger 1985:129). Facilities that could simulate reentry conditions of space vehicles were paramount during this early period of ARC. By 1962, almost half of the research conducted at ARC was dedicated to entry and environmental physics, and new facilities paralleled these new research directions (Muenger 1985:128-129). New facilities dating to the early 1960s included the Hypervelocity Research Laboratory (Building N230), 3.5-foot Hypersonic Tunnel (Building N229), the 20-inch Hypersonic Helium Tunnel (Building N231) (**Photograph 1**), the 1-foot Hypervelocity Shock Tunnel, the Mach 50 Helium Tunnel (Building N238), the Hypervelocity Free-Flight Facility, the Impact Range, and the Gasdynamics Laboratory (Building N234).

Photograph 1. Hypersonic Helium Tunnel, 1961.

The development of research tunnels and other apparatuses was a key component of the research capabilities. Heat-transfer and low-density tunnels were in continuous development to improve their simulation of reentry airflow speed or aerodynamic heating (Hartman 1970:284). In attempting to improve on the operational problems of the heat-transfer and low-density tunnels, ARC researchers led by Glen Goodwin and Alfred Eggers looked to develop helium tunnels to provide adequate heat and stable conditions for testing. In 1958, Goodwin and Eggers each designed a helium tunnel facility; plans for a 12-inch by 12-inch helium tunnel with an unheated blowdown, fixed nozzles to produce airflow speeds of Mach 10, 15, 20, and 25, attached to pressurized cylindrical helium tanks and spherical recovery tanks. In 1960, the proposed helium tunnel was actually constructed as a 20-inch-square helium tunnel (Building N231) (**Figure 1**), along with a 14-inch helium tunnel in a separate facility. Both tunnels achieved their projected Mach numbers, but could not provide adequate heating or stability with the application of intense shock waves and other complex conditions. The limitations of the helium tunnels led ARC research engineers to concentrate more on the development of arc jets, which could potentially simulate reentry conditions comprehensively (Hartman 1970:330-331).

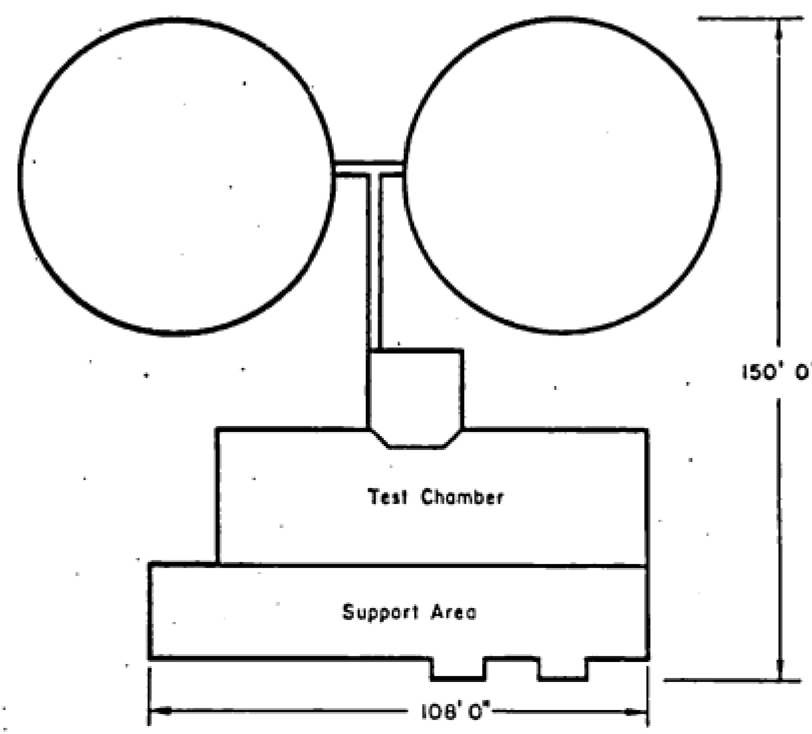


Figure 1. Plan of the Hypersonic Helium Tunnel (Building N231), 1967 (ARC 1967).

The Hypersonic Helium Tunnel represented an early period in the evolution of technology at ARC to simulate reentry conditions for testing. Using its facilities such as the Hypersonic Helium Tunnel, ARC developed thermal protection systems that were crucial for every NASA space program, including Apollo, Space Shuttle, Viking, Pioneer-Venus, Galileo, Mars Pathfinder, MER heatshield, Stardust, NASP, X-33, X-34, SHARP-B1 and B2, X-37 WLE TPS and most recently CEV/Orion heatshield development and Mars Science Laboratory TPS (nasa.gov).

ARC dismantled the Hypersonic Helium Tunnel as its technology became obsolete in the 21st century. Currently, the building serves as offices and shops in support of the Arc Jet Complex. The complex is dedicated to the use of high-powered arc jets, including the Interaction Heating Facility, the Panel Test Facility, the Turbulent Flow Duct, and the Aerodynamic Heating Facility. The facility remains critical for TPS thermal models, designs, and flight qualification (nasa.gov).

Evaluation and Significance:

NRHP Criterion A
Constructed in 1960, the Hypersonic Helium Tunnel (Building N231) is associated with scientific innovation and the development of hypersonic wind tunnel technology during an important early period of NASA's mission to achieve manned spaceflight and a lunar landing in the 1960s. The innovation of the helium tunnel represented an important stage in the evolution of technology at ARC to simulate reentry conditions for testing.

The Hypersonic Helium Tunnel is eligible for the NRHP under Criterion A for its association with the creation and operation of helium tunnels and its contributions to important scientific research related to space exploration, for a period of significance from 1960, the year that it was constructed until the date the Hypersonic Helium Tunnel was fully dismantled.

NRHP Criterion B
The Hypersonic Helium Tunnel is associated with several scientists and researchers who had long and productive careers at ARC, and who contributed to science. Glen Goodwin and Alfred Eggers were the proponents for the design and development of the facility, but the facility is not a significant representation of either individual's career or historical contributions. It does not meet NRHP Criterion B.

NRHP Criterion C
The design of the Hypersonic Helium Tunnel once represented a highly specialized research facility, with one laboratory building attached to wind tunnel equipment and helium tanks and spherical recovery tanks. However, removal of the helium tunnel equipment has altered the design of the facility. While the laboratory building appears relatively unchanged, it does not represent a distinctive design as an individual research facility anymore. The Modern architectural characteristics of the building, including its horizontality, continuous windows, and awnings, are representative, but do not convey a level of significance to meet NRHP Criterion C. The remaining helium spherical recovery tank is distinctive, but not unique. The facility does not meet NRHP Criterion C.

NRHP Criterion D
Information related to the design and development of the Hypersonic Helium Tunnel is well documented. The facility does not, and is not likely to yield information regarding history or prehistory. Therefore, the property does not meet NRHP Criterion D.

Integrity Analysis:

Location
The Hypersonic Helium Tunnel remains in its original location at ARC.

Design
Substantial alterations have removed the major operational components of the facility and have introduced new additions, significantly diminishing the integrity of the Hypersonic Helium Tunnel's design.

Setting
The Hypersonic Helium Tunnel is located on the ARC campus, surrounded by other highly specialized research facilities of varying design. No new major facilities are present in its immediate vicinity. Overall, the Hypersonic Helium Tunnel retains integrity of setting.

Materials
The Hypersonic Helium Tunnel has been significantly altered with the removal of its equipment. Material losses of the tunnel and the accompanying spherical recovery tank have diminished its integrity.

Workmanship
The Hypersonic Helium Tunnel has been significantly altered with the removal of its equipment. The workmanship related to the helium tunnel is no longer evident, and the facility's integrity of workmanship is diminished.

Feeling
Because the Hypersonic Helium Tunnel retains its general exterior appearance and setting, it retains integrity of feeling, although somewhat diminished by the removal of a spherical tank and the absence of an atmosphere of experimentation.

Association
The Hypersonic Helium Tunnel is associated with important research and the development of wind tunnel technology related to the early era of NASA's mission to achieve manned spaceflight and a lunar landing in the 1960s. This association is no longer evident as the tunnel equipment has been removed and the remaining building of the facility has been repurposed as a general workshop.

Summary:

The Hypersonic Helium Tunnel (Building N231) meets NRHP Criterion A for its association with the creation and operation of helium tunnels and its contributions to important scientific research related to space exploration, for a period of significance from 1960, the year that it was constructed until the date the Hypersonic Helium Tunnel was fully dismantled. However, due to the removal of its significant equipment, the former Hypersonic Helium Tunnel facility lacks integrity of design, materials, workmanship, and association to be eligible for the NRHP.

References:

ARC
1967 *Technical Facilities Capability Catalog*. On file at ARC.

Hartman, Edwin
1970 *Adventures in Research: A History of Ames Research Center, 1940-1965*. NASA.

Muenger, Elizabeth A.
1985 *Searching the Horizon: A History of Ames Research Center, 1940-1976*. NASA.

Nasa.gov
n.d. "Arc Jet Complex." Available at: http://www.nasa.gov/centers/ames/thermophysics-facilities/arcjet-complex.

Vincenti, Walter G., John W. Boyd, and Glenn E. Bugos
2007 "H. Julian Allen: An Appreciation," *Annual Review of Fluid Mechanics* 39 2007:1–17.

State of California — The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary #
HRI #
Trinomial

*Resource Name or #: Building N242 – Structural Dynamics Laboratory

P1. Other Identifier: Systems Development Facility

***P2. Location:** ☐ **Not for Publication** ☑ **Unrestricted** ***a. County:** Santa Clara
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5' Quad:** San Francisco North **Date:** 1995 **T** N/A; **R** N/A **¼ of¼ of Sec ; B.M.** S.B.B.M.
c. Address: 955 Mark Avenue City: Moffett Field Zip: 94035
d. UTM: Zone: ;
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate) Elevation:
The resource is located at the NASA Ames Research Center, on Mark Avenue between Boyd Road and Walcott Avenue.

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)
Building N242 is a two-story research facility with a rectangular plan and a prominent 100-ft. pentagonal test chamber tower extending from the center of the building. The building has reinforced concrete walls that are scored with a grid pattern. The building and the tower have flat roofs. The building has two sections: the laboratory and test areas, including the tower, to the south, and offices and shops to the north. The sections are divided without internal access.

The south portion of the building containing the laboratory has a central, two-story bay enclosed with a sliding hangar door on the south side of the building that provides access to the laboratory test areas (pictured below). To the left, there is a two-story bay that contains corrugated metal siding with a pair of steel doors under a concrete canopy in the first story, and fixed metal-framed windows in the first and second stories. The east side of the building contains roll-up steel utility doors in the first and second stories, although the first story door has been modified with a single glazed steel door. The west side of the building contains no doors or windows. The east and west sides have regularly spaced vent openings in the second story.

The north portion of the building containing offices and shops has entrances on the east and west sides, each consisting of recessed glazed doors and surrounds under five, tall and narrow fixed windows with projecting concrete dividers. To the north of each entrance, a concrete mass projects from the building. The north side of the building has eight symmetrical bays containing narrow fixed clerestory windows in the first story and large, recessed, single-plate, fixed windows in the second story. Mechanical equipment is also located along the north side of the building.

***P3b. Resource Attributes:** (List attributes and codes) HP39 – Other: Research laboratory

***P4. Resources Present:** ☑Building ☐Structure ☐Object ☐Site ☐District ☐Element of District ☐Other (Isolates, etc.)

P5a. Photo or Drawing (Photo required for buildings, structures, and objects.)

P5b. Description of Photo: Building N242, south side, view facing north.

***P6. Date Constructed/Age and Sources:** ☑Historic ☐Prehistoric ☐Both
1965

***P7. Owner and Address:**
NASA Ames Research Center
Moffett Field, CA 94035

***P8. Recorded by:**
AECOM
401 W A Street
San Diego, CA 92101

***P9. Date Recorded:** 7/23/2015

***P10. Survey Type:** Intensive

***P11. Report Citation:** Section 106 Consultation on the Arc Jet Complex Steam Vacuum System Boiler Replacement and Relocation Project at Ames Research Center, Moffett Field, California, NASA, 2015

***Attachments:** ☐NONE ☐Location Map ☐Sketch Map ☑Continuation Sheet ☑Building, Structure, and Object Record ☐Archaeological Record ☐District Record ☐Linear Feature Record ☐Milling Station Record ☐Rock Art Record ☐Artifact Record ☐Photograph Record ☐ Other (List):

BUILDING, STRUCTURE, AND OBJECT RECORD

***NRHP Status Code** 3S

***Resource Name or #** Building N242 – Structural Dynamics Laboratory

B1. Historic Name: Systems Development Facility
B2. Common Name: Building N242
B3. Original Use: Research facility **B4. Present Use:** Offices and laboratory
***B5. Architectural Style:** Contemporary
***B6. Construction History:** (Construction date, alterations, and date of alterations)
Construction began in 1964, and operation began in 1966. The building was repurposed in 1972. Changes to the south facade include alteration of the windows. No major exterior alterations.

***B7. Moved?** ☑**No** ☐**Yes** ☐**Unknown** **Date:** **Original Location:**
***B8. Related Features:** None

B9a. Architect: NASA
b. Builder: NASA
***B10. Significance:** Scientific Research **Theme:** Research facility **Area:** Ames Research Center, Moffett Field
Period of Significance: 1965 **Property Type:** Research facility **Applicable Criteria:** A and C
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

See Continuation Sheet.

B11. Additional Resource Attributes: (List attributes and codes)

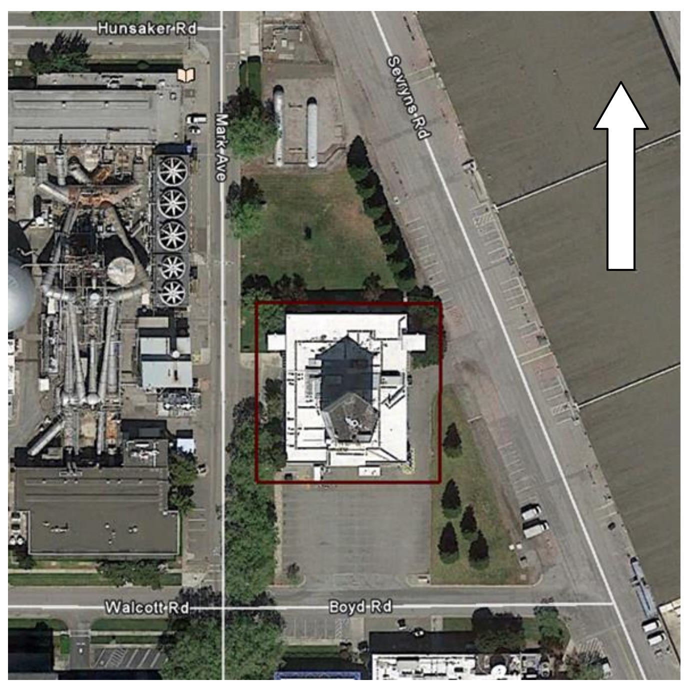
***B12. References:**
See Continuation Sheet.

B13. Remarks:

***B14. Evaluator:** M.K. Meiser, M.A., AECOM

***Date of Evaluation:** 7/23/2015

(This space reserved for official comments.)



 ***Required information**

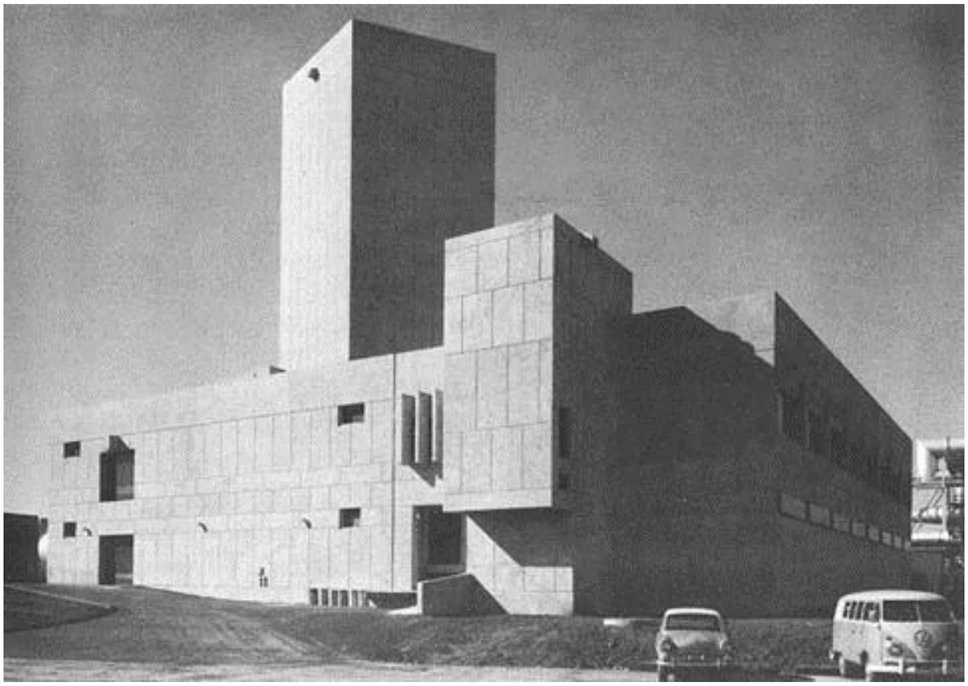
***B10. Significance:** (continued)

When the National Aeronautics and Space Administration (NASA) was formed in 1958, its primary goals were manned spaceflight and a lunar landing as part of the space race with the Soviet Union after the launch of *Sputnik* in 1957. Ames Research Center (ARC), formerly the National Advisory Committee for Aeronautics (NACA) Ames Aeronautical Laboratory, refocused its energies and resources to the new, space mission-oriented projects, including the goal of landing a man on the moon by the end of the 1960s. NASA's projects received higher budgets and new facilities to accomplish these goals. In addition to its established research in aeronautics, ARC added divisions dedicated to space-related research, including life sciences, flight simulation, and thermal protection.

In 1953, Ames theorist Harvey Allen published his seminal work on the blunt-body concept for ballistics reentry into the Earth's atmosphere, which also would enable the safe reentry of spacecraft (Vincenti, et al. 2007:1). To test the blunt-body theory, Ames researchers began developing ways to simulate the conditions of launch, spaceflight, and reentry of space vehicles. Beginning in 1956, Ames began addressing the need to reproduce the extreme heat that space vehicles would encounter upon reentry to the Earth's atmosphere. NASA instructed ARC to focus on testing the thermal and aerodynamic facets of Harvey Allen's blunt-body theory. In 1959, ARC reorganized its two high-speed, space-related divisions under Allen's direction. The Aero-Thermodynamics Division included several branches: the Supersonic Free-Flight Wind Tunnel Branch; the Heat Transfer Branch; the Fluid Mechanics Branch; and the Transonic Aerodynamics Branch. The Vehicle Environment Division included the Physics Branch; Entry Simulation Branch; Structural Dynamics Branch; the 3.5-foot Hypersonic Wind Tunnel Branch; and the Hypervelocity Ballistic Range Branch.

In the early 1960s, ARC had a "frantic spurt of building," more than doubling the value of its research facilities from 1958 to 1965 (Muenger 1985:129). The Structural Dynamics Branch of the Vehicle Environment Division, led by Al Erickson and Henry Cole under Allen's direction, developed a specific interest in the dynamic structural loads of spacecraft and their launching vehicles. Research focused on addressing launch-vehicle instability, landing-impact attenuation, and fuel-sloshing loads. This research required a new facility, and in 1964, construction began on the $1.65 million Structural Dynamics Laboratory (Building N242) (Hartman 1970:426) (**Photograph 1**). The new facility featured a 100-foot-tall tower with a massive pentagonal test chamber. The deliberate pentagonal design avoided the development of a strong standing wave pattern. The test chamber was equipped with moderate vacuum, infrared heating, vibration with variable-frequency shakers, and noise as produced by a rocket motor to simulate lift-off forces (Bugos 2010:135). The equipment, simulating ascent and descent through Earth's atmosphere, was used to test the launch and landing of space vehicles. One of the specific goals of the new facility was to test buffeting in new hammerhead ballistic missiles (Bugos 2010:135). Erickson and Cole ran the laboratory and experimented with launch vehicle instability and fuel sloshing. Researchers also used the facility to test the structural strength for a composite space shuttle vehicle and to assist in the design of shuttle and spacecraft landing gear to withstand landing impact (Bugos 2010:135-136).

By 1972, ARC closed its Vehicle Environment Division, and repurposed the Structural Dynamics Laboratory for other experimentation. By 1974, it was renamed the Systems Development Facility. Several research programs used the facility for various testing over the decades. In 1976, the Mars Wind Tunnel (MARSWIT) began operation in the facility. MARSWIT is part of the Planetary Aeolian Laboratory, which is used for simulating Aeolian processes (windblown particles) of the atmospheres of Earth, Mars, and Saturn's moon Titan, administered by Arizona State University, and funded by NASA's Planetary Geology and Geophysics program. MARSWIT is "used to investigate the physics of particle entrainment by the winder under terrestrial and Martian conditions, conduct flow-field modeling experiments to assess wind erosion and deposition on scales ranging from small rocks to landforms (scale) such as craters, and to test spacecraft instruments and other components under Martian atmospheric conditions" (Williams 2013:1). In addition, the Planetary Aeolian Laboratory in Building N242 includes the Titan Wind Tunnel (TWT). The TWT began as the Venus wind tunnel, which operated in 1981–1994. TWT is a closed-circuit, pressurizable wind tunnel upgraded in 2012 with a newer, higher performance motor, advanced motor controls, and new instrumentation (Williams 2013:1). Into the 21th century, the Planetary Aeolian Laboratory continues to use Building N242 in the physical research to carry on NASA's mission.



Photograph 1. Structural Dynamics Laboratory, circa 1970 (Hartman 1970:425).

The facility and its capabilities and functions were described according to ARC's 1967 *Technical Facilities Capability Catalog* (ARC 1967) (**Figure 1**):

> The facility consists of 19,000 square feet of test areas and shops. The principal test area is a central pentagon-shaped tower surrounded by smaller test areas which utilize the tower walls for strong-back mounting. The inside dimensions of the tower are 26'-6" on each of the five sides and 101 feet to the ceiling. Access to the tower is through a 25 x 25 foot door. The tower can be evacuated to an atmosphere of 4 millimeters of Mercury and the roof can support a suspended load of 1,000,000 pounds. Under low pressure the ceiling supports have a reduced capacity with a minimum value of 150,000 lbs. The chamber has a total volume of 140,000 cubic feet. Its primary function is for environmental testing of aerospace structures under thermal, acoustic and vibration loads. The tower can also be used for drop testing for impact studies.
>
> The laboratories adjacent to the tower include an aeroelastic area for elastic wind-tunnel model checkout, a 30-foot high bay area with a 22' x 22' door for static and low frequency structural testing, a light test area for small scale experiments and a photoelastic area for research in structural stress.
>
> Present equipment in the laboratory consists of a 50KIP and 200 lb. materials testing system, a 2,000 watt acoustic horn, and a number of electrodynamic shakers ranging up to 500 pounds in output force. Frequency response, power spectral density and correlation function analyzers and associated measuring equipment are available. A laboratory air supply of 50,000 cu. ft/min. at 125 psi is available for acoustic testing. Control equipment for 7.6 megawatts of radiant heat installed, lamps available for 700,000 watts of radiant heat; 400 gpm hydraulic pumping capacity at 3,000 psi, four servo controlled hydraulic force actuators of 250,000 lbs each, 20,000 lb electro dynamic shaker with 9-inch stroke are available.

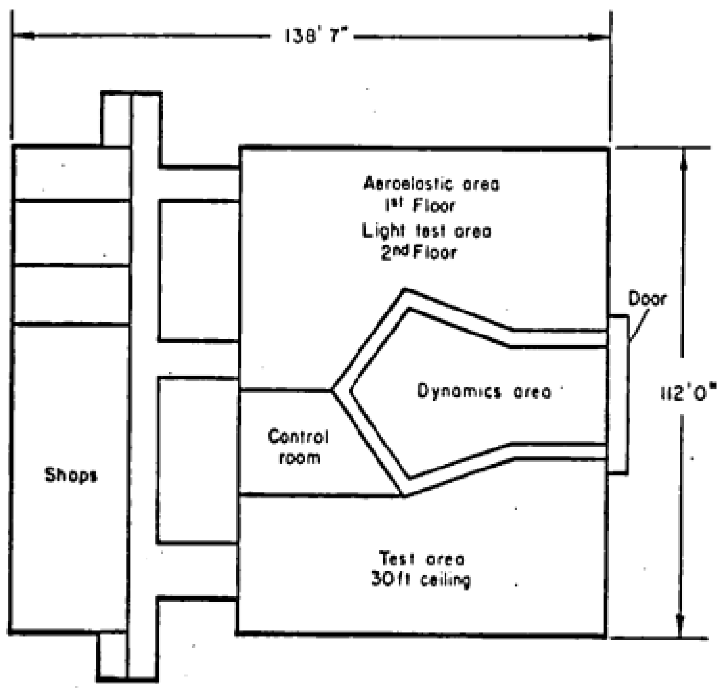


Figure 1. Plan of the Structural Dynamics Laboratory (ARC 1967).

Evaluation and Significance:

NRHP Criterion A
Constructed in 1964, the Structural Dynamics Laboratory (Building N242) is associated with scientific innovation in the development of missile and spacecraft research facilities during an important early period of NASA's mission to achieve manned spaceflight and a lunar landing in the 1960s. The Structural Dynamics Laboratory is eligible for the NRHP under Criterion A for its association as a highly specialized missile and spacecraft testing facility, and for its contributions to important scientific research related to space exploration. The period of significance extends from 1964 to 1972, the year construction began until the Structural Dynamics Branch at ARC terminated and the building was repurposed for other uses.

NRHP Criterion B
The Structural Dynamics Laboratory is associated with several scientists and researchers who had long and productive careers at ARC, and who contributed to science. Al Erickson and Henry Cole were the proponents and directors of the facility, but neither researcher has historical contributions that qualify them as important historic individuals, and the facility is not a significant representation of either individual's career or body of work. It does not meet NRHP Criterion B.

NRHP Criterion C
The design of the Structural Dynamics Laboratory is distinctive as a highly specialized research facility, particularly with the prominence of its 100-foot pentagonal tower. The Modern architectural characteristics of the building, including its horizontality, scored concrete walls, and stylized entrances on the east and west side convey its period and method of construction, and it aesthetically represents the modernity related to the Space Age. For its distinctive design and form, Building N242 meets NRHP Criterion C.

***Recorded by:** AECOM ***Date:** 7/23/2015 ☑Continuation ☐ Update

NRHP Criterion D
Information related to the design and development of the Structural Dynamics Laboratory is well documented. The facility does not, and is not likely to yield information regarding history or prehistory. Therefore, the resource does not meet NRHP Criterion D.

<u>Integrity Analysis:</u>

Location
The Structural Dynamics Laboratory remains in its original location at ARC.

Design
The Structural Dynamics Laboratory has had no major alterations to its exterior design or to its general configuration.

Setting
The Structural Dynamics Laboratory is located on the ARC campus, surrounded by other highly specialized research facilities of varying design. No new facilities or structures have intruded on its setting.

Materials
No changes to the materials of the Structural Dynamics Laboratory have been observed.

Workmanship
No changes to the workmanship of the Structural Dynamics Laboratory have been observed.

Feeling
Because the Structural Dynamics Laboratory retains its design, setting, materials, and workmanship, the feeling of the building as mid-century research facility is intact.

Association
The Structural Dynamics Laboratory is important as a highly specialized space vehicle testing facility, for its contributions to important scientific research related to space exploration, and for its distinctive design. Although the original program for the building ceased in 1972, it has been in continuous use as a research facility focusing on atmospheric conditions. No major alterations are evident. Therefore, it retains its integrity of association.

<u>Summary:</u>

The Structural Dynamics Laboratory (Building N242) is significant under NRHP Criterion A for its association as a highly specialized missile and spacecraft testing facility, and for its contributions to important scientific research related to space exploration. It is also distinctive as a specially designed Modern research facility with a prominent 100-foot-tall pentagonal tower, and meets NRHP Criterion C. The period of significance extends from 1964 to 1972, the year construction began until the Structural Dynamics Branch at ARC terminated and the building was repurposed for other uses. The Structural Dynamics Laboratory sufficiently retains its integrity of location, design, setting, materials, workmanship, feeling, and association to be eligible for the NRHP.

References:

ARC
1967 *Technical Facilities Capability Catalog*. On file at ARC.

Bugos, Glenn E.
2010 *Atmosphere of Freedom: Seventy Years at the NASA Ames Research Center*. Washington, D.C.: National Aeronautics and Space Administration Special Publication-2010-4314.

Hartman, Edwin
1970 *Adventures in Research: A History of Ames Research Center, 1940-1965*. NASA.

Muenger, Elizabeth A.
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